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THE ARSENIC CONTENT OF FILTER ALUM

EDWARD BARTOW AND A. N. BENNETT

Specifications requiring arsenic free alum for water treatment by several European[1] purification plants suggested that it would be advisable to make determinations of the arsenic content of the filter alum used in this country and particularly of that used in the state of Illinois.

It is well known that products which are manufactured with the aid of commercial sulphuric acid quite generally contain more or less arsenic, depending upon the purity of the acid used. The poisonous character of arsenic compounds, even when present in small amounts, makes it of general interest and importance to have definite knowledge of the presence or absence of arsenic in any substance which enters directly or indirectly into foods or drinks. Sulphuric acid is used in the manufacture of filter alum and it is therefore quite essential, particularly to those who are in public health work, to know whether arsenic in any considerable amounts is being added to drinking water in the process of purification with alum.

We have been unable to find any definite published data relating to the arsenic content of filter alum. Dr. George A. Soper several years ago made an investigation of this problem, and referred to his results while discussing a paper by Mr. E. E. Wall[2] on "Water Purification at St. Louis, Missouri." Dr. Soper was discussing in par-

[1] Jour. f. Gasbel, 56, 882 (1913).
[2] Trans. Am. Soc. C. E., 60, 202-9.

ticular the use of sulphate of iron in water treatment and spoke in the following manner:

> There is a final point which the speaker hesitates to mention, but, inasmuch as before this society it will probably be taken in the conservative spirit in which it is intended, and may lead to useful inquiries, it may be referred to briefly. It concerns the composition of the sulphate of iron used. . . . What are the impurities in this sulphate? How much arsenic is there in this sulphate? Some years ago the speaker had occasion to examine specimens of sulphate of aluminium from a good many filter plants and found arsenic in nearly all of them. It is true, that usually the arsenic was not present in large quantities, but it was easily discoverable, and in some of the samples it was present in sufficient amount to be of more than passing interest. The arsenic, of course, came from the sulphuric acid used in making the sulphate of aluminium, the sulphuric acid having been produced from pyrites which contained arsenic.

From Dr. Soper's first remark it is evident he realized that, due to the increasing public prejudice against the use of any material containing arsenic or other similar poison, a great injustice might be worked upon both the manufacturer and the plants that use alum for water treatment, by giving widespread publicity to this matter; at least, before all phases of the problem had been thoroughly investigated. The writers, too, are of this same opinion and so have refrained from mentioning the names of any manufacturers whose product have been examined and have also omitted the name of all filter plants outside the state of Illinois.

We have found but one other reference to the arsenic content of water treatment materials. In further discussion of the same paper and relative to sulphate of iron, Mr. E. E. Wall, in reply to Dr. Soper's statements, said:

> The writer has a copy of a report . . . . in which it is stated that no arsenic was found in any of the samples tested and that the small quantity of arsenic in the sulphuric acid used in cleaning steel is, without doubt, removed in the cleaning tubs in the form of arsenureted hydrogen, thus leaving the liquors from which copperas is made, free from arsenic. Even if there should be a minute quantity of arsenic in the sulphate of iron, it is scarcely possible that this could remain in the water after treatment with the quantity of lime used at St. Louis.

The explanation of the absence of arsenic in sulphate of iron due to its loss as arsine is quite feasible but such is not the case with sulphate of aluminium. Filter alum is made by digesting bauxite with the required amount of sulphuric acid, consequently all or prac-

tically all of the arsenic present in the acid will remain in the finished product.

We have not been able to learn that anything has been done in this country to regulate the amount of arsenic in filter alum. The purification plants, at least in the state of Illinois, have made no effort to obtain an arsenic free article. The manufacturers of alum keep more or less accurate records of the arsenic content of their product. The writers have found only one producer who advertises "arsenic free alum." Neither the government nor any of the states has promulgated legislation regulating this product, although there is a regulation concerning arsenic in other substances entering into foods. The government has set a limit for arsenic in coal tar dyes and in baking powder of one part in 700,000. This very low limit, particularly when it is considered that only relatively small amounts of these substances are used in food preparation, shows that considerable importance is attached to the presence of arsenic and its compounds.

SAMPLES

In order that results might be of greatest value by showing the condition of the alums as they are actually used, as many samples as possible were first obtained directly from the water purification plants in Illinois. Twenty-six plants use alum in treating water. The purpose of the investigation was explained to the managers of each plant. They were asked to coöperate by furnishing a sample of the alum used, together with the name of the manufacturer or dealer supplying the same. Twenty-two of the plants very promptly complied with the request, and in nearly every case expressed decided interest in the subject with a wish to know the results of the investigation.

Owing to expense of transportation practically all of the alum used in Illinois is supplied by three manufacturers. In order to make our study more complete we have extended the scope of our investigations and have secured samples from practically all of the large manufacturers of alum in the country. In some cases the samples came directly from the producer, and in others from the water treatment plants. The specimens of alum were carefully sampled, ground and analyzed in duplicate by the following methods.

METHODS OF ANALYSIS

The method used in obtaining most of the data given is a modified Gutzeit method, developed by Mr. Claude R. Smith[3] in his work on coal tar dyes and other food constituents. The results obtained by this method were in several cases checked by the Marsh-Berzelius method[4] and were found to agree. The Gutzeit method has been investigated by Sanger and Black[5] and others for quantitative work, and, when proper care is taken in the manipulation, has been found to give satisfactory results. The chief modification proposed by Smith is the use of paper sensitized with mercuric bromide instead of mercuric chloride, which had previously been generally used. The bromide gives more permanent stains and the standards can be kept longer. The method depends upon the formation of a dark orange stain when the generated arsine is brought in contact with the sensitized paper. The apparatus used is essentially as described by Smith. The generator is a 50 cc. wide mouth Erlenmeyer flask. This is connected with two upright tubes 8 cm. in length and 1 cm. in diameter, the lower containing lead acetate paper and the upper filled with cotton moistened with 5 per cent lead acetate solution. Fitted into the upper tube by means of a rubber stopper is a capillary tube 3 mm. in internal diameter and 12 cm. in length. This capillary is constricted at two joints about 3½ cm. from each end. By this means the sensitized paper is held in the center of the tube thus producing stains of equal length on both sides of the paper. Under uniform conditions, the length of the stain varies with the amount of arsenic present. A series of standard stains prepared from known amounts of arsenic are used for comparison. A convenient series is made from 2, 5, 7.5, 10 and 15 micromilligrams. The amount of arsenic in the weight of alum taken is determined by matching the stain it produces with the standards; it is then a matter of simple calculation to determine the percentage arsenic content or the parts per million of arsenic. A one gram sample will contain as many parts per million of arsenic as there are micromilligrams of stain obtained. For example, if one gram of alum produces a stain which matches the 5 micromilligram standard stain, then that alum contains 5 parts per million. One part per million

[3] U. S. Dept. Agr., Bur. of Chem., Circular No. 102.
[4] U. S. Dept. Agr., Bur. of Chem., Circular No. 99.
[5] J. Soc. Chem. Ind., 26, 1115 (1907).

is equivalent to 0.0001 of one per cent. A stain representing between 5 and 25 micromilligrams gives the most satisfactory results. A stain between these limits can be obtained by varying the weight of alum used.

For the analysis of alum containing more than 30 parts per million As_2O_3, another method proposed by Smith, was used. The generated arsine is passed into mercuric chloride solution (10 cc. of 5 per cent $HgCl_2$ diluted to 100 cc.). According to Smith probably several different arsenides of mercury and some free arsenic are formed. These are oxidized by the excess of mercuric chloride, slowly in the cold and rapidly on heating, forming arsenous acid and mercurous chloride. The mercurous chloride can be filtered off and weighed and the arsenous acid in the filtrate determined by titration with iodine. In this way checks are obtained in the one determination. The equation used for the calculation of arsenic from the weight of mercurous chloride obtained is:

$$2AsH_3 + 12HgCl_2 + 3H_2O = 12HgCl + As_2O_3 + 12HCl$$

Thus $1As_2O_3$ is equivalent to 12HgCl.

As an alternative the conglomerate precipitate can be titrated by means of iodine. Sufficient potassium iodide is added to form the soluble double potassium mercuric iodide and then an excess of standard iodine solution. When all the precipitate has gone into solution the excess iodine is titrated with standard thiosulphate. The iodine absorption represents the oxidation of arsine to arsenic acid in which 1As is equivalent to 8I.

As usual all reagents used were tested to prove their freedom from arsenic.

DETERMINATION OF ARSENIC

Five grams of finely ground alum are dissolved in the generating flask in 30 cc. sulphuric acid (1–4) with the aid of heat. Four or five drops of a 40 per cent solution of stannous chloride in concentrated hydrochloric acid are added and the solution cooled. Four or five grams of arsenic free moss zinc are now added and the lead acetate tubes and capillary containing the sensitized strip are connected. The evolution of gas is allowed to proceed for at least one hour. The stain, after drying, is then compared with the standards. A steady, brisk but not violent evolution of gas should be maintained. This can be regulated by varying the acidity, volume of solution, amount of zinc and temperature. After a little experience very

uniform results can be obtained. In the determination of larger amounts of arsenic it is necessary to allow the evolution of gas to proceed for two or three hours.

The sensitized paper is made from heavy, close-textured drafting paper, cut into strips 2.5 mm. by 12 cm. These strips are soaked for an hour in a 5 per cent alcoholic solution of mercuric bromide. The excess solution is squeezed off and the strips allowed to dry.

The results from the samples obtained from the Illinois purification plants are given in Table I, those from outside the state in

TABLE I

Arsenic as As_2O_3 in Filter Alums used in Illinois

CITY	ARSENIC AS As_2O_3		GALLONS*
	Pts. per mil.	Per cent	
Cairo	1.6	0.00016	3213
Carlinville	1.8	0.00018	2856
Charleston	1.2	0.00012	4283
Chicago and Rogers Park	1.4	0.00014	3671
E. St. Louis and Granite City	0.8	0.00008	6425
Decatur	1.4	0.00014	3671
Elgin	1.6	0.00016	3213
Evanston	1.4	0.00014	3671
Ft. Sheridan	1.2	0.00012	4283
Hamilton	1.4	0.00014	3671
Kankakee	0.8	0.00008	6425
Kenilworth	1.4	0.00014	3671
Lawrenceville	3.0	0.00030	1713
Macomb	1.6	0.00016	3213
Moline	1.0	0.00010	5140
Mt. Carmel	2.0	0.00020	2570
Mt. Vernon	1.2	0.00012	4283
Pana	1.2	0.00012	4283
Quincy**	1.0	0.00010	5140
Quincy**	4.0	0.00040	1285
Rock Island	2.0	0.00020	2570
Rock Island Arsenal**	1.6	0.00016	3213
Rock Island Arsenal**	1.0	0.00010	5140
Streator	3.4	0.00034	1512

* Gallons of water containing a minimum medicinal dose of 2 mgm. when the water is treated with 6 grains of alum per gallon, provided that all the arsenic remains in solution.

** Two samples from different manufacturers.

Table II. In all cases the arsenic is recorded as arsenic trioxide, As_2O_3. Twenty-four samples from Illinois plants and seventeen from sources outside the state were analyzed.

The results obtained by analyzing alum used in Illinois clearly show that arsenic in exceedingly small amounts is always present in filter alums. We find a minimum of 0.8 part per million (0.00008 per cent) and a maximum of 4.0 parts per million (0.0004 per cent) of arsenic as As_2O_3 in the alum used by Illinois water purification plants. If a water were treated with alum containing the maximum amount of arsenic found, at a rate of 6 grains of alum per gallon, an amount which is very seldom exceeded, and if all the arsenic were soluble and remained in the filtered water, since arsenic is not a cumulative poison, a person must drink 1285 gallons of the treated water at one time to obtain a medicinal dose of 2 mgms. From this it is readily seen that the arsenic content of filter alum used in Illinois is of no significance.

TABLE II

Arsenic in Filter Alum Obtained from Sources Outside the State of Illinois

SAMPLE NO.	ARSENIC AS As_2O_3		GALLON*
	Pts. per mil.	Per cent	
1	0.5	0.00005	10280.0
2	1.2	0.00012	4283.0
3	1.2	0.00012	4283.0
4	1.4	0.00014	3671.0
5	2.6	0.00026	1977.0
6	2.6	0.00026	1977.0
7	4.0	0.0004	1285.0
8	4.0	0.0004	1285.0
9	5.0	0.0005	1028.0
10	20.0	0.0020	257.0
11	27.0	0.0027	190.0
12	31.0	0.0031	166.0
13	49.0	0.0049	105.0
14	280.0	0.0280	18.0
15	941.0	0.0941	5.5
16**	1240.0	0.124	4.0
17	1240.0	0.124	4.0

* Gallons of water containing a minimum medicinal dose of 2 mgm. when the water is treated with 6 grains of alum per gallon, provided that all the arsenic remains in solution.

** Nos. 16 and 17 were obtained from the same plant and are probably from the same lot of alum.

The samples obtained from sources outside the state showed a wider range in arsenic content. In one case there was 0.5 part per million (0.00005 per cent), and in nine cases there was more than in the highest Illinois sample, the maximum being 1240 parts per million of arsenic as As_2O_3 (0.124 per cent).

If a water were treated with alum containing 1240 parts per million As_2O_3, at the rate of 6 grains per gallon and provided all the arsenic remained in solution, 0.13 part per million of arsenic as As_2O_3 would be added and a medicinal dose of 2 mgm. would be contained in four gallons. This would be quite an appreciable amount and is more than should be added in water purification. However, owing to the insolubility of the arsenites and arsenates of calcium, magnesium, aluminium and iron, a large part of the arsenic would be removed with the precipitated aluminium hydrate. To determine the extent of this removal, if any, several experiments were carried out.

Two liters of water were treated at the rate of 6 grains per gallon with an alum containing 941 parts per million of As_2O_3. By this treatment 188 micromilligrams of As_2O_3 were added. Forty micromilligrams of As_2O_3 were recovered from the filtered water and 144 from the sludge. Thus only 22 per cent of the arsenic remained in solution.

Some water was treated at the rate of 20 grains per gallon with an alum containing 1240 parts per million of As_2O_3. Only 12 per cent remained in solution.

A sample of filtered water was obtained from the filtration plant using this latter alum. It had been treated at the rate of 200 pounds of alum per million gallons or at the rate of 1.4 grains per gallon. From this water only 7 per cent of the arsenic originally added was recovered from the solution. Thus a removal of 93 per cent of the arsenic was effected by the purification process.

CONCLUSION

Filter alum used by water purification plants in Illinois does not contain a significant amount of arsenic. Some filter alum used elsewhere contains a much larger amount of arsenic, but since at least 75 per cent of the arsenic added in the treatment of water with alum is removed with the precipitated aluminium hydrate, there is a strong probability that in no case a sufficient quantity of arsenic would be added to the filtered water to have therapeutic

significance. However, since alum containing an insignificant amount of As_2O_3 can be readily obtained, the manufacturers should make an effort to keep the arsenic content of their product at a minimum and water works officials should demand an article practically free from arsenic.

We wish to express our appreciation of the assistance rendered by the manufacturers and water works officials who furnished us samples for examination.

DISCUSSION

Mr. James M. Caird: This was a very interesting paper which has just been presented by Dr. Bartow, and the large amount of data is of great value. The speaker does not like the use of the word alum, when really sulphate of alumina is meant. The general public has an awful horror of that word *alum*. Bringing up the subject of arsenic; the medical profession is very strict about the use of any water supply where alum or sulphate of alumina is used for purification, and now to think that Dr. Bartow is using alumina which contains arsenic: why, they are likely to go up in the air a little farther. Within two months a letter was received from an official of a state department of health, in which he says he would never be convinced that there was not some sulphate of alumina in the filtered water, although tests failed to show it. Now if that is the feeling in some of the health departments, if they think that there is arsenic too, what will they do about it?

The question of contaminating drinking water by using, for its purification, sulphate of alumina containing arsenic has often been discussed, and it has invariably been found that, even if the sulphate of alumina used contained determinable quantities of arsenic, no trace of arsenic was found in the filtered water. First, because part or all of the arsenic is precipitated with the ferric or alumina hydroxide formed in the purification process and filtered off. Second, because the small amount of sulphate of alumina used per gallon of water would bring down the arsenic content in the water to indeterminable traces, even if no arsenic was removed by the purification process. The Pharmacopeia of the United States requires that a chemical to be pure may contain not over ten parts per million of As_2O_3.

It is permissible to refer to the Royal British Committee appointed to investigate the so-called "Manchester beer scare" in 1901. This

committee gave the result of their investigations at the meeting of the London session of the Society of Chemical Industry in January, 1902. Their recommendation was chiefly on the method of testing for minute quantities of arsenic, and the discussion following was more or less of a farce. One member of the committee, a medical man, Dr. James Edmunds, doubted whether they had reached the real cause of the illness and death in the Manchester epidemic. He had been in the habit of prescribing arsenic and giving two or three milligrams per dose three times a day for a good many weeks, and had never known a case of arsenical neuritis to result. Most of the cases were proved to be alcoholic neuritis, not arsenical neuritis. One of the patients, who was confined to bed for three months with what was supposed to be arsenical neuritis, had been a total abstainer all his life, so that beer could hardly be blamed for his case. In short it has never been positively proven that the arsenic found in Manchester beer was the cause of the epidemic of neuritis in Manchester. Presumably that is why it is known as the "Manchester beer scare."

Arsenic is found so frequently everywhere in nature that it is impossible that natural water should not contain more arsenic than would ever be put in by using sulphate of alumina for its purification. All clays, ochres, iron ores, etc., contain arsenic, and all the waters from the most famous mineral springs, where people go for their health, contain arsenic in considerable quantities. Vichy, two parts per million; Carlsbad, varying from determinable traces to twenty-five parts per million. The late Sir Edward Franklin positively found arsenic in the atmosphere of London. Arsenic is found in the waters of the Rhine, Nile and in the Delaware river; in many vegetables, such as lettuce, beets, etc., but this must be considered dangerous ground, as all the acid phosphates used as manure contain large quantities of arsenic.

Mr. Charles A. Jennings: The speaker had a practical application of this paper by Dr. Bartow, just a very short time ago. One of the packing firms in Chicago had a shipment of alum turned down by the government because it contained 125 p.p.m. of As_2O_3. As a result they were willing to sell that alum for about 15 cents per hundred pounds less than the regular price we were paying for alum.

MR. JAMES M. CAIRD: A case in the speaker's own family might be of interest; in this instance "arsenora" a compound of arsenic and gold has been used for the past fifteen years. The dose reaches, at times, as high as sixty drops per day before producing any trouble to the eyes.

DR. EDWARD BARTOW: We did analyze the water that had been treated with the alum containing arsenic, and actually found about nine per cent of the arsenic remaining in the filtered water. That was an actual test that we made.

MR. JAMES M. CAIRD: Did you try the raw water too, and could not find any there?

DR. EDWARD BARTOW: There was no arsenic in the raw water.

MR. A. ELLIOTT KIMBERLEY: Are there any cases on record suggesting arsenical poison through water?

DR. EDWARD BARTOW: Not to the author's knowledge.

MR. PHILIP BURGESS: Is there any germicidal action of the arsenic?

MR. WILSON MONFORT: Regarding that, the speaker has been watching with a good deal of interest the development of a mold in a tenth normal alkaline arsenious acid solution for some time, so arsenic is not necessarily fatal to vegetable organisms.

METHODS OF WASHING SLOW SAND FILTERS

By John Gaub[1]

In late years various processes for cleaning the sand of a filter bed have been advanced; some partly destroying and others exterminating the filter film on the bed. These ideas have in some cases caused trouble and in others only repair. There is no doubt that the rough treatment of the sand surface, a penetration of organic matter and filth into the bed cause deep clogging, which prevents the yield of water, and causes the beds to become inefficient.

Attempts to reduce the work of cleaning filters are commendable, because scraping, sand handling and raking are the items of greatest expense in slow-sand filter maintenance; hence it is the endeavor of the writer to show what attempts along this line have been made, both from an economical and efficient standpoint.

In this country it is bad economy to discard the sand scraped from the filters, for the expense attached to the preparation of new sand is very high, since it must be washed free from clay and screened before it is ready to be placed in the filter. Yet in Osaka, Japan, the sand is dredged from the Yodo river opposite the water works, and made suitable for the beds and placed therein for about 65 cents per cubic yard, a figure so low that no attempt is made to recover by washing the sand scraped from the filters.

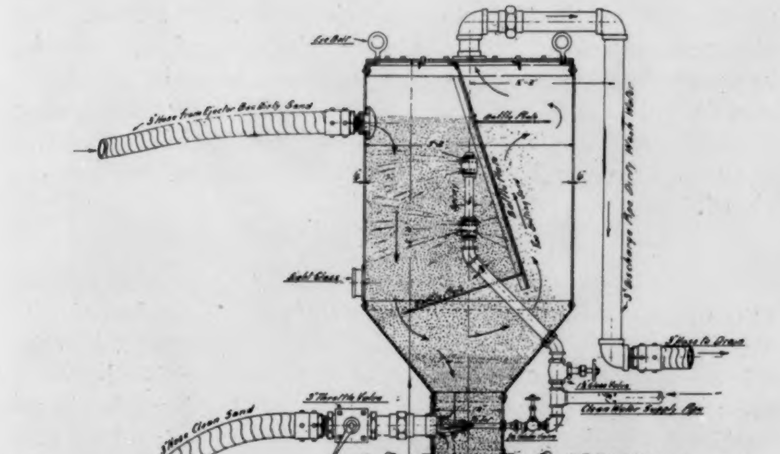
In handling the sand for slow sand filters several methods have been tried, each giving results at a small cost in some places, while in others the contrary is true. The writer, therefore, compiled tables from plants using these methods, together with their costs. However, before delving into the methods as practiced at the various plants, a brief description of the methods commonly used will not be out of place.

THE BROOKLYN METHOD

This method was first used in 1905 at the Hempstead filters, at Rockville Center, Long Island, and consists in lowering the water to

[1]Supt. Filtration Plant, Washington, D. C.

SAND WASHER IN USE AT TORONTO, CANADA



PORTABLE SAND WASHER IN USE AT TORONTO, ONTARIO, CANADA

a few inches in depth above the surface of the sand on the filter. Unfiltered water is taken from an adjacent filter in service and run in a stream over the bed to the outlet drain, a depth of about 1 inch of flowing water being maintained over the section to be cleaned. Men in boots agitate the surface of the sand with long-toothed garden rakes, thus stirring the dirt from the sand and having it carried away to the drain. The filter is generally cleaned in sections by cutting off the part undergoing cleaning from the rest of the filter by boards set on edge and driven down into the sand, forming a miniature flume with board sides. After cleaning, the boards are removed to a new position. When the filter is clean, filtration is resumed. This method is somewhat costly, in that about 1 per cent of wash water is used. In cases of emergency it has given good results. At Philadelphia, it is reported that with 14 men and a foreman a three-quarter acre bed can be cleaned in eight hours and that such a bed will be out about nineteen hours a month.

SAND WASHING MACHINES

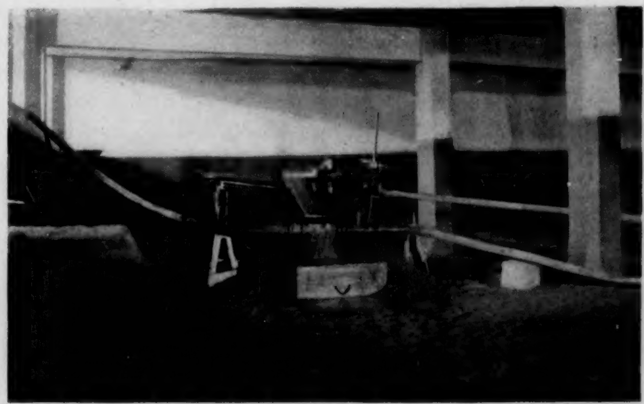
These machines are recent additions to the washing apparatus used in slow sand filters. They began their existence about 1909 when the Washington plant adopted the "ejector washer" system. Previous to this time the dirty sand, after being scraped, was shoveled into portable ejectors on the beds, to be thence forced by water pressure through pipes to stationary sand washers. After being washed, the sand was discharged into storage bins, from which carts driven underneath may be loaded, and the sand carried to the filter and placed.

THE BLAISDELL MACHINE

This machine may be described as a traveling crane spanning a filter unit and supporting a watertight rectangular chamber containing the machinery necessary, and provided with means for lowering this chamber to the sand surface and traveling over the filter while the process of washing is in progress. The chamber wherein the washing takes place may be raised so as to clear the rim of the filter and thereby remove the machine to another filter.

About 2 inches above the sand or bottom of the sand chamber there is a plate or diaphragm dividing the washing chamber into two compartments placed above each other; the lower, used as a suction chamber from which the dirty wash water is withdrawn, contains

Sand Washer at New Haven, Connecticut



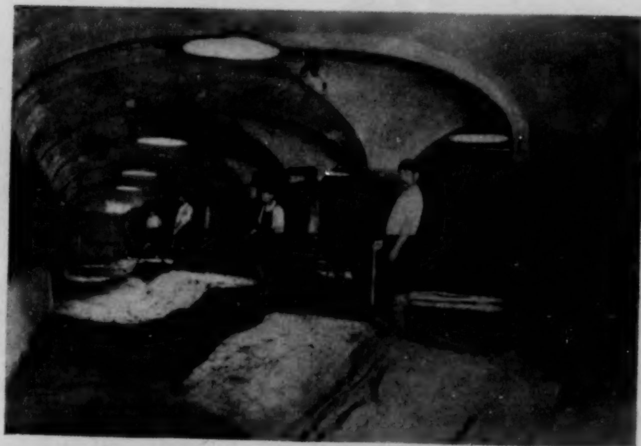
Hopper Sand Ejector at New Haven, Connecticut

stirrer wheels mounted on vertical shafts; the upper contains the driving mechanism for the stirrer wheels and also the pressure and suction pumps.

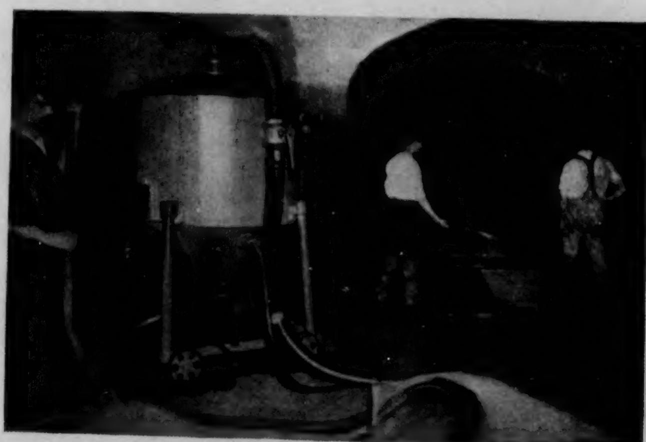
From the stirrer wheels, in the lower chamber, supported on vertical shafts above the sand, numerous teeth project into the sand to any desired depth. The teeth are hollow and perforated in order to create a water jet action from the supply delivered by the pressure pump. The water for the pump is taken from the water on the filter, while at the same time a suction pump joined to the top chamber withdraws not only all the water the pressure pumps supply through the perforated teeth, but also an additional amount from the filtered water in the sand. In operation, the teeth scour the sand, while the wash water by its jet action drives the dirt into the suction chamber and the clear water stored in the filter bed is drawn into the washing zone by the excess suction over the pressure supply, and the wash water is pumped from the supply before the machine passes a given point. The chamber is placed close to the surface of the sand by shoes extending in advance and to the rear of the front end back plate, while the side plates cut down into the filter sand.

The pressure water rises through the disturbed sand zone and is displaced by the inrush of clear water, the upward current of which occurs well toward the center of disturbance created by the teeth and covered by the suction chamber. The sand is forced apart by the teeth, and as they return the strong upward current of wash water causes a temporary suspension and churning action within the suction chamber. During this time the dirt and light particles are brought to the surface and withdrawn with the wash water. The sand in suspension settles after the violent upcast subsides, so that when the sand comes to rest it is uniformly water packed and free from air. The wash water from the machine is discharged to a gutter formed generally in the party wall between filter units. The wash water may be so controlled that sizing may be done by working all very fine sand to the surface and removing that which is too fine from the filter. This sizing is done by increasing the duty of the pressure and suction pumps so as to secure a downward velocity by which to hold the sand in suspension.

All of the operations of this machine are controlled by separate motors which are operated from a platform. Generally there are six motors mounted on the machine with variable speed controllers, With this machine it is possible to wash a bed of an acre in about



Replacing Sand Machine at Torresdale



Replacing Sand by Machine at Torresdale

twelve hours, and in about fifteen hours the bed can be in service, allowing three hours for closing valves, etc.

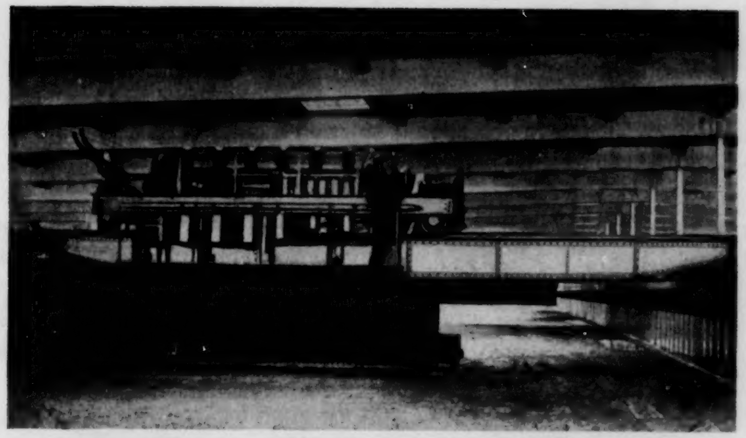
THE NICHOLS WASHER

This machine has been in use since 1910. It enables the operator to wash the sand on the filter without removing it from the bed, thereby saving not only in wash water, but also in labor, etc.; in other words the total saving being about 35 per cent of what it would cost to use the old method of scraping, removing, washing and replacing the sand. Briefly, the machine consists of an inverted cylinder inside a closed jacket. The dirty sand is fed into ejectors in the usual way, and the wash water with the sand and dirt passes through the machine. The water strikes the side of the cylinder, and the sand being heavy drops to the bottom and passes through a nozzle on to the filter. About 2 per cent of fine sand passes out with the water and dirt to the court where it generally settles while the débris goes to the sewer. It has been shown at some places that it is possible to clean 10 cubic yards per hour using 1200 gallons of water per cubic yard, whereas by the old method 2800 gallons of water were used. Again, at some places this machine has been modified, in that several sprays of water play on the sand within the machine; also more baffles have been added, thus causing a better wash for the sand.

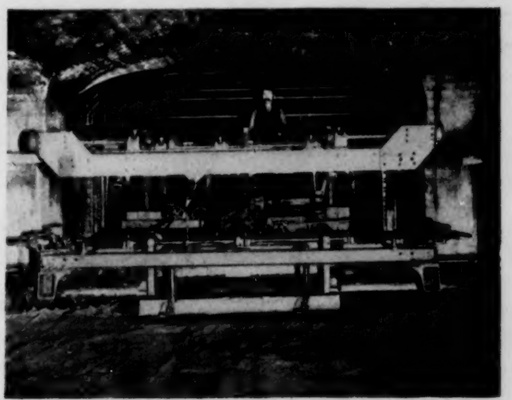
METHODS OF WASHING SAND AT DIFFERENT PLANTS

Washington, D. C.

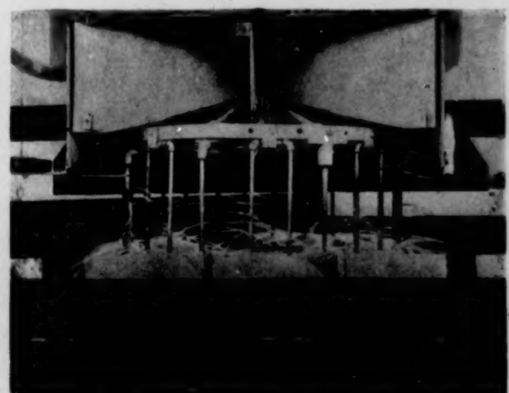
Until 1909 the filters were scraped and the sand piled, and then removed by ejector and one or more lengths of hose to the sand washers. After the sand was washed, it was discharged into storage bins from which carts were loaded and the sand brought to the desired place on top of the bed, and there dumped and spread evenly. After 1909 the hydraulic method of replacing was used, whereby an ejector is placed underneath the outlet gate in the storage bin, and the sand is carried in a reverse direction from the bin through piping and one or more lengths of hose to the bed. This process has decreased the cost of resanding and has proved very satisfactory in every way. This method has been used or tried in several places with more or less good results. At Washington the filters are resanded as follows: the filters are filled with water to the desired depth



Sand Washing Machine at Wilmington, Delaware



Sand Washing Machine Open, Showing the Different Parts



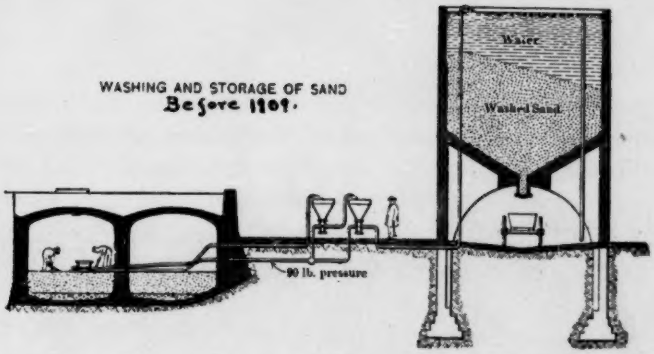
Sand Washing Machine Showing Jets

of the sand layer. The outlet end of the hose is joined to a 3 inch pipe supported on a boat, and the sand is discharged through the pipe at the point required. Generally work is begun at the far end of the filter, and is gradually filled by swinging the boat from side to side and backing it by degrees to the front end. By this method the sand has no tendency to separate into different sizes, if the discharge has a slope of about 40 to 45 degrees from the horizontal. By this position of the discharge pipe the old surface of the sand is cut and moved ahead with the new sand, thus breaking up the possibility of forming a mud layer between the old and new layers. The following is the average cost of scraping, ejecting, washing, transporting, replacing and raking.

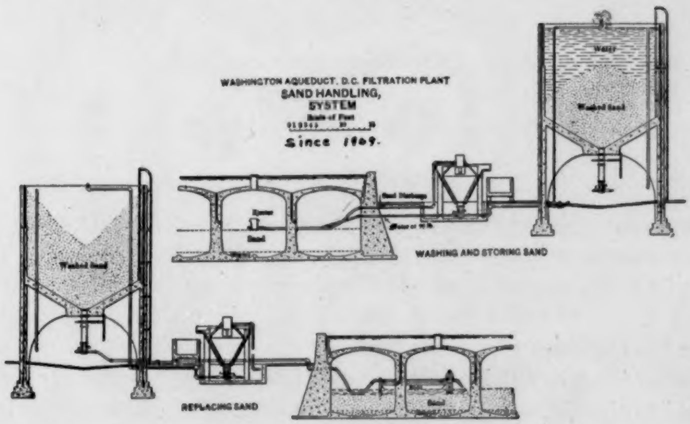
SCRAPING			RAKING		
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.	Per acre
$0.096	$0.07	$16.08	$0.042	$0.03	$6.64
EJECTING, WASHING AND TRANSPORTING			REPLACING		
.168	.11	28.32	.08	.06	

Sand Ejectors. The movable ejector is novel for two reasons: (a) The water for making the sand into suspension is brought up from the bottom and rises as the sand is shoveled into it, thus producing a mixture having more sand in proportion to water. (b) The discharge ends of the ejector are made like the discharge end of a Venturi meter, with a flat batter. The economy herein lies in the fact that use is made of the velocity head in the throat, which is lost with the batter made in the usual way. For a more detailed description of these ejectors and the tests whereby they were tested, the reader is referred to Vol. 57, 1906, of the *Transactions of the American Society of Civil Engineers.*

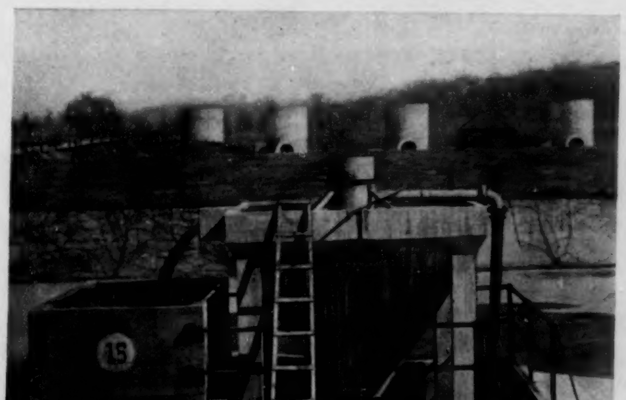
Sand Washers. The sand washer used here differs from the usual type of washer, in that the mixed sand and water fall into the hopper. From the hopper there is a free opening to a chamber formed by a globe casting. A second jet of water enters this chamber near the bottom, and is carried into the throat of the ejector with the sand as it leaves the hopper. The sand settles through the water into the chamber and is separated from all dirty water which came



WASHING AND STORING SAND AT WASHINGTON, D. C. (BEFORE 1909)



WASHING, STORING AND REPLACING SAND AT WASHINGTON, D. C. (SINCE 1909)



WASHING SAND AT WASHINGTON, D. C.

with it. The hopper usually used dilutes the dirty water in the sand, but the one devised at Washington makes a complete separation.

Toronto, Canada

Sand is washed by a portable washer. After being scraped in piles it is put into an ejector box from which it is carried to the washer. In the washer it passses through sprays of clear water, and by the action of baffles, falls to the bottom, where a strong spray drives it out through a hose, which distributes the clean sand on the filter. The wash water used is about $\frac{1}{3}$ per cent of the net yield of the filter. The wash water passes up to the top of the washer, then down to a 3-inch drain which connects with a 36-inch drain. The cost per cubic yard of sand, washed and replaced, including washer pump, handling sand, repairs, etc., is about $0.61.

Denver, Colorado

The sand is conveyed from the filters to the washer through an ejector and sand line of hose at a pressure of about 150 pounds. In this plant the ejector method of replacing was tried, but owing to stratification, was abandoned. The cause of stratification probably was a too high uniformity coefficient of the sand as it left the washer. The sand is replaced from dump cars, the cars being loaded by hand, hauled to the side of the bed by horse power, dumped, reloaded into side dump cars, pushed by hand to the place desired, dumped and spread. This is very costly, but owing to the thoroughness of mixing, it appears to be the best in the end. The total cost per cubic yard for cleaning and washing the sand on a bed is about $0.73.

New Haven, Connecticut

Here the water is drawn off and the sand piled, and wheeled to the hopper and carried to the washer by hydraulic means. From the washer the sand goes to a receiver in the bed having the lowest depth of sand, in which it is spread around and allowed to accumulate until the maximum depth of 40 inches is reached, when the apparatus is put into the next bed having the least depth. By this process about 5 cubic yards per hour can be washed, using about fifteen volumes of water to one of sand. The cost of cleaning per acre is about $75 not including the cost of water. About 60 cubic yards of sand are removed per cleaning, making the cost per cubic yard about $0.43.

Albany, New York

Up to 1910 the sand was washed and handled by the ejector method, but replaced by hand. In 1910 the Nichols machine was introduced and the cost of cleaning and replacing was reduced 44 per cent. However, there has been some trouble with the beds in this plant due to the formation of two filter-films caused by putting the new sand on the beds after forking the sand that remained there. The procedure of forking at the junction of ejected sand caused this film to increase until the turbidity of the sand ran 3–5000 and the output of the eight beds fell to 10 million gallons per day. However, the cost since 1910 to 1914 and 1899 to 1900 is as follows:

July 1899–1900

	per mil. gal.
Scraping	\$0.25
Wheeling out sand	.50
Washing sand	.59
Refilling	.39

In 1910 a comparison was made between the Nichols machine and the box-sand washer with the following results:

Cost per cubic yard by box-sand washer	\$0.409
Cost per cubic yard by Nichols	.226

Since 1912 and including 1914, the following is an average cost per million gallons.

Scraping	\$0.07
Ejecting	.12
Washing and replacing	.16
Reforking beds	.01
Total	.36

Lawrence, Massachusetts

The sand is ejected to a set of three hoppers outside the bed. The sand from the last hopper is ejected to a large box having a weir which holds back the sand and permits an overflow of waste water. The sand is then shovelled out from the box down one of the ventilation holes for distribution on the bed. The cost per cubic yard is about 25 cents. It is claimed at this plant that the wheeling of the sand to the desired place and casting insures proper mixing, while the use of water pressure causes stratification due to the uniformity coefficient of the sand.

Pittsburgh, Pennsylvania

This plant has tried scraping, raking and washing machines. However, it appears that they are somewhat expensive, since the last four years, 1911–14, the hydraulic method was used and adopted. In the reports this method is known as the "Washington Method." The following summary gives an idea of the average cost.

SCRAPING			EJECTING	
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.
$0.175	$0.314	$25.42	$0.254	$0.450
RAKING			RESTORING SAND	
Per cu. yd.	Per M. G.	Per acre	Per cu. yd.	Per M. G.
$0.061	$0.064	$8.90	$0.087	$0.147
WASHING AND TRANSPORTING				
.120	.213	17.52		

Philadelphia, Pennsylvania

At Torresdale, the sand washing pumps had not been installed at the time of starting the plant, so another method of washing was resorted to, viz: the Brooklyn, as described above. This method was used until March, 1908, with little success, due to the sediment, organic matter, and micro-organisms forming a paste-like layer extending about 4 inches in depth. The consistency of the filter film was so at times that it could be removed in cakes. The runs were short and after about 100 million gallons had been filtered spading was tried in order to get the water through the filters. By this process, the surface of the filter was gone over with a spade and thrust down to a depth of 8 inches, and worked back and forth to break the layer. This caused an increased drop in efficiency with little assistance in length of runs. Next, the piling method whereby the sand is piled, waiting to be washed at some future time, was adopted, and it gave good results.

About 1909 Mr. Nichols designed a machine which today is used very much, by which it is possible to save 25 cents per cubic yard

in sand handling. The advantage of this machine is that the thickness of the filter is not reduced while the danger of breaking through is decreased, and the efficiency not affected by the change in the rate of each filter. At this plant raking is practiced to the extent of two or three times per scraping. The following is a summary of the costs of the various methods used at Philadelphia:

REMOVAL		PILING	BROOKLYN	RESANDING
Per M. G.	Per cu. yd.	Per M. G.	Per M. G.	Per cu. yd.
$1.46	$0.43	$0.58	$1.68	$0.26
NICHOLS		RAKING	SPADING	
1.22	.41	.12	.38	

Springfield, Massachusetts

The methods used here are practically similar to those used at Washington, D. C. The following is a summary of the costs:

	M.G.
Cleaning	$0.36
Resanding	.17
Raking	.09

Wilmington, Delaware

At this plant a very good example of the Blaisdell machine is seen. The machine is used for raking and washing the sand on the beds. It was expected that the cost of sand washing, etc., would not be greater than one dollar per million gallons. However, since the plant requires intelligent superintendence at all times, and skilled mechanics for operating the washing machine, and notwithstanding that the machine is idle about 70 per cent of the available working time, the cost has been a little over the expected cost. The following summary gives an idea of the requirements of the machine together with the costs.

Average kw. per bed	115
Cost of kw. per bed	$3.45
Total cost per M.G.	1.23

The total cost per million gallons is an approximate sum, but the other figures are averages for the years 1911–14.

YIELDS

Having considered the methods for washing the sand of the various slow sand filters, it now becomes our duty to consider the different methods as to yields.

Philadelphia, Pa. (Torresdale)

1907–12 (SUMMARY)

	Yield, million gallons				Days run		
	max.	*min.*	*av.*	*rate*	*max.*	*min.*	*av.*
Brooklyn	67	4	19	1.8	49	6	14
Removal	379	10	74	3.6	105	4	27
Nichols	569	30	150	4.4	148	11	45
Rake 1	280	3	85	4.7	75	2	24
Rake 2	120	17	52	4.6	31	6	15
Rake 3	73	17	41	3.9	24	5	14
Piling	167	3	35	2.6	19	2	18
Spading	90	11	51	4.5	22	4	15

Washington, D. C.

	AV. NUMBER OF RUNS ENDING		DURATION IN DAYS (AV.)		AV. MILLION GALLONS FILTERED		
1905–10	143.4		66		170.13		
	Rake	Scrape	Rake	Scrape	Rake	Scrape	Total
1910–14	75.5	84.2	56	68.5	119.87	150.24	270.11
Springfield, Mass.							
1913	23	22	44	48	79.08	98.29	177.37
1914	24	26	40	44	77.15	84.64	161.79

Wilmington, Del.

	PER CENT TIME OUT	DAYS OPERATED PER WASH	YIELD PER WASH	YIELD PER RUN
			M. G.	M. G.
1911–12	2.10	13.4	14.127	24.372
1912–13	3.0	20.5	9.817	39.877
1913–14	2.3	23.8	7.133	45.648

From these tables it will be seen that each method has its advantages and disadvantages. The Blaisdell machine is very economical in that the time in which a filter is out is practically at a minimum; however, the days in which the filter is operated after the wash are somewhat at a minimum also. As for total yields the processes as practiced at Washington and Torresdale appear to show up better. However, from a standpoint of duration in days the Washington methods are the best and cheapest.

CONCLUSIONS

From the experiences at the various plants cited it is seen that much improvement in sand handling has been in progress, especially in building machines.

The cost of cleaning a filter by machine has not been reduced below that for cleaning and replacing sand by the improved hydraulic processes.

The uniformity coefficient of the sand is an important factor to consider when hydraulic processes are used.

The hydraulic processes as practiced at Washington and Springfield are the cheapest and most economical.

ACKNOWLEDGMENT

The writer is indebted to all those who have given him data regarding their respective plants; also the New England Water Works Association for the cuts on the Nichols machine at Torresdale; this Association for the cut on the Blaisdell machine at Wilmington, Delaware.

ASSESSING COSTS OF EXTENSIONS IN A MUNICIPALLY OWNED PLANT

By D. A. Reed[1]

It has been generally conceded that certain civic improvements or conveniences constructed or furnished by a municipality may not be wholly paid for by general taxation, but may be assessed as special benefits against abutting property. This assessment may cover the costs in whole, or in part, but the principle is recognized that a local improvement of any nature must of necessity carry with it some direct benefit to the abutting property. It is also true that no improvement can be made without some benefit to the municipality at large. With improvements of this nature we may properly class sewers, street improvements of all kinds, water works, gas plants, and possibly other utilities.

An improvement of any kind which is largely local in nature, that is, which from the nature of its construction is largely an accommodation to the abutting property only, is found in lateral sewers and water mains of minimum capacities supplying or serving local properties only, and which do not provide capacities in excess of local requirements, and which are not indispensable for serving more distant territory.

Street improvements, including pavements, curbs, gutters and culverts, trunk sewers and the larger sizes of mains in the distribution of a water or gas supply, serve to accommodate a less restricted area and cannot be considered as strictly local in their nature. A pavement for instance, on one street alone, might well be considered as a benefit to some extent of all the property within the city limits or even outside of the city limits, although its greatest benefit would be to the property adjacent, a sewer, however, might be entirely local so far as its benefits are concerned and be of no value whatever to any other property.

The logical method for assessing the cost of any improvement, the product of any utility, or the benefits from any service rendered, is

[1] Manager Water and Light Department, Duluth, Minn.

upon the interests directly benefited. In private business where one interest often benefits largely from the enterprise of another, there is no practicable method of applying this rule unless they are customers or purchasers of the products of that utility, and even then the costs are often disproportionate to the service rendered on account of the escape of such interests from the contribution as do not purchase directly the products of that enterprise.

A city owned utility usually has the power to assess certain benefits, whether the party interested chooses to be a consumer or not. Applying this fact to sewers and water mains the proper method would be to assess the costs of construction, or in other words, the capital investment, against the property that it is possible to serve. The costs of operation, however, should be levied against the parties purchasing the output or using the service.

Sewers, after they have been constructed and the costs having been met by all the property owners served, regardless of whether they are connected or not, should be operated at the expense of those only who use or are connected with it. The operating costs, however, are relatively small and are not usually assessed but are paid out of the general fund supported by general taxation. In a street improvement it would be manifestly impracticable to assess costs of operation against those served or who use the utility; in a manner, however, this is accomplished by means of a wheelage tax, the receipts of which are applied to operating expenses.

In the case of a municipal water supply, these matters seem to be much easier of solution and it seems quite practicable to assess costs of construction directly upon the property susceptible of being served, and to assess the operating costs directly upon the customers or patrons of the utility, in proportion to the quantity of water consumed. This condition it must be observed is not met entirely by a rate charged upon a demand and output basis such as is in effect in New Orleans, for the reason that the demand charge does not extend to vacant property.

To those who believe that vacant property should not escape taxation for any improvement that directly enhances its value, this fact will appeal. It would also seem to be a fair check or restraint upon interests that invest in idle property with a view of gain which results largely from the activities of others and in which its existence directly increases the cost of every utility that passes the premises.

It is assumed that a municipal water plant should be self-sustain-

ing in every sense of the word. It should neither give nor receive any benefit or consideration of any kind from the taxpayer, the city or the individual.

A water main in which the size is in excess of the minimum may be classified as serving two purposes, the service to the property directly abutting and the service to properties located more distantly from the source of supply. In the first instance, for the purpose of this discussion, a 6-inch service may be considered as sufficient, and for all sizes in excess of 6 inches, for the additional service to those more distant. Assessments against abutting property for the 6-inch main are easily applied. For costs of mains in excess of this size the only practicable way appears to consider the additional cost as a part of the general distribution system, the expense of which has to be absorbed by the utility and included in the consumers' rates chargeable as operating costs. The direct assessment to the abutting property for the 6-inch main, this size being used as a matter of convenience, may be assessed against the abutting property by means of either of two methods. First, in the total, on the completion of the work, which is paid by one assessment. Second, the principal being furnished from the funds of the utility a percentage may be assessed annually against the property to cover interest and sinking fund upon the investment. After a term of years the percentage assessment will have returned enough money to the utility to cover the principal as well as interest upon the investment. Ordinarily the vacant property thus assessed should continue to pay the assessment for the full term of years necessary to wipe out the original costs. Improved property, using water and paying for it upon meter rates would be entitled to some credit or rebate on account of these rates, especially if the rates are based upon capital investment expense as well as operating costs upon the entire plant. Assuming for the purpose of illustration that one-half of the water rates are to cover interest and sinking fund expense, and that the balance is to cover operating costs including depreciation, it will be found necessary to credit one-half of the customer's water rates against his assessment. This credit will ordinarily retire the annual percentage assessment upon improved property, unless the cost of constructing the extension was large and the consumer's consumption was low. If his consumption is considerably more than necessary to wipe out his individual assessment, the surplus, of course, should be applied pro rata to lessen the tax upon the vacant prop-

erty. It is quite possible for the consumption on an extension to increase to such an extent that the overplus of credits will be sufficient to retire all the assessment against the vacant property upon that particular extension, in which case, having reached that point, all assessments should be discontinued as the customers are carrying the entire expense of the extension, including capital investment as well as operating costs. This even may be accomplished at the end of one year or two years or possibly ten or fifteen years, depending upon the rate of the percentage assessment against the property, the interest and sinking fund factor in the rates charged for the water, and the amount of the consumption upon the extension.

It is also quite possible an extension may be made where there is no consumption for the first year. In this case all the property pays the percentage assessment with no credits and the utility receives the exact amount necessary to pay interest and sinking fund charges.

The method employed at Duluth, Minnesota, in which a gas utility is also operated in connection with the water system, the pipes being laid in the same trench, has been to assess annually against the abutting property, 8 per cent of the total cost of each extension as represented by a 4-inch gas and a 6-inch water main, it having been established that sizes in excess of these dimensions would be more or less of a general benefit to all customers and property and for the strengthening of the system to benefit other customers outside of those served by that particular extension. The proportion of charges against the abutting property has been based upon 5 per cent for interest and 3 per cent for sinking fund assessed annually for a period of fifteen years, 3 per cent contribution to a 4 per cent sinking fund however will not retire the principal short of 22 years, but for various reasons it has been considered advisable to limit the duration of annual assessments to a fifteen-year term. A special discount of 25 per cent is allowed to those paying the total amount in one payment. These assessments are made according to the frontage of the lot, without reference to its depth. However, the frontage of the lot is not considered necessarily as being the side abutting the street upon which the extension is made. It may lie parallel to the mains and front on another street. It is assessed the same as other lots of the same frontage dimension. Subsequently if mains are laid in front of the short side no assessment is made therefor on this particular lot, which can of course, receive no benefit from a second extension. Against this assessment is credited one-half of the water

and one-third of the gas rates paid by the occupant of the premises, it being estimated that these proportions are necessary factors in a rate that will yield the proper amount of revenues for maintaining and operating the plant.

The principles and results involved in the methods as outlined above seem to be as follows:

1. All charges whether of installation or of operation against property or a customer are based upon actual cost.

2. Costs of distributing systems are ordinarily borne by abutting property except when the consumption is sufficiently large to assume the whole or part of this expense when the charge is gradually transferred to the customer.

3. The customer bears operating costs and such installation charges as cover reservoirs, pumping machinery, stations, intakes and the larger distributing mains.

4. As the municipal plant increases in size and in the amount of its revenues, its percentage of indebtedness will gradually decrease, the proportion of interest and sinking fund in the rates charged for water will decrease until eventually, when no indebtedness exists, this factor will become zero and there will be no credits against the assessments. They will have to be met in full cash payments or the consumer may discount the entire amount of his individual assessment by paying cash, taking advantage of the 25 per cent discount.

5. The percentage plan enables the small property owner who is a consumer to obtain extensions on very easy terms, with practically no additional expense over and above the regular water rates.

6. It seems to be a practicable way for real estate owners to secure extensions of gas and water service in newly platted additions without throwing any of the burden upon the utility or its customers.

7. It furnishes a profitable investment at 8 per cent net for the sinking funds of the department until the time arrives when it will be needed to retire bonds, at which time, if the money or any portion of it cannot be withdrawn, refunding bonds or new bonds in whole or in part may be issued. Eventually, if the rates for service have been correctly established, the time will be reached when its entire indebtedness will be retired. This will be true if depreciation and maintenance have been provided for in the operating expenses as well as interest and sinking fund on the indebtedness.

DISCUSSION

Mr. Wirt J. Wills: The speaker does not suppose there can be any absolute rules for these kinds of extensions and probably it might be well for some of us to tell how it is done in our own towns. In Memphis, Tennessee, a municipally owned plant, the water board, laid one hundred foot extensions to the houses. Should a subdivision be opened up without any houses on it, the owners of the subdivision have to take advantage of what we call the "water-note plan," which is a note made up like any other note only it says, "payable in rentals from water without interest so many dollars;" for instance, the man that gives this note advances the money and all of the revenues out of that line are credited up to him until all the money that the main cost has been returned to him. In that way probably 40 per cent of the resident district of Memphis has had mains put in and a great many of them are already paid for. Some of them are not quite paid up yet. Of course when it comes under construction the man that advances the money takes all the burden of the scheme. If we put down a main for a man for a subdivision and it is not developed properly and is perhaps sold for a brick-yard, all the burden then comes on him if it is not a success.

Mr. John M. Diven: Does that apply only to new development, or to all extensions?

Mr. Wirt J. Wills: You know that Memphis is about all extended except newly annexed territory out in different places. One street was opened up by one of the water commissioners, in the heart of the residence section, and he had to put up fourteen hundred and sixty dollars just the same as if he had been any other man; but, except in new territory, there is very little in the suburbs that is not annexed. We find it comparatively satisfactory, people get their money entirely back and it is satisfactory to us.

Mr. J. M. Diven: That money comes out of the revenue; it is never capitalized?

Mr. Wirt J. Wills: It is simply treated as an advancement of the money, or bills payable.

Mr. J. M. Diven: It does not appear in your capital account?

Mr. Wirt J. Wills: The money advanced is credited to a separate account known as "water note account" (or bills payable). The main laid is charged to construction the same as all other mains laid are charged.

Twice a year the amount paid for the use of water from said main is returned to the party who advanced it, and charged to "water note account." This money is paid out of a fund derived from the sale of bonds, the same as all construction is.

However, the legal advice on the subject is, in this state, when a water company or municipality makes enough money to pay its interest, to create a sinking fund, pay all its expenses, and the price of water is equitable, any other moneys earned "can be used for construction if necessary."

In this scheme, the man who wants the main at once, simply advances the money without interest, and it is returned to him according to the main's earning capacity.

Mr. John M. Diven: If all of your construction and extensions were provided for in that way you would have no capital account for the distribution system, and no interest on that part of the construction would appear in the operation cost of the works.

Mr. Alexander Milne: The suggestion of the Secretary is perhaps comparable to the method adopted by a careful individual as to his own house and lot. A municipally owned water works is simply a collective individual interest and if it were necessary to expend any sum within the ability of the finances for renewals or extensions, and it could be done from "savings" from revenue account without further bonding or mortgaging the "collective" property, the effect would be equally good financing as if done by the individual on his own. This practice has been followed in the St. Catharines plant whenever possible; from 1905 to 1912 the savings having been sufficient to finance from time to time the construction of over twelve miles of distribution mains and some 2000 new services, the commission deeming it better financial policy not to reduce the rates because they had a surplus revenue for the time being, as our rates are low compared with other cities of our class, but rather to accumulate a reserve for any emergency or such extensions when required, all of such work being charged up to capital account, and increasing the assets on the balance sheet.

The principle is one, however, that has to be governed largely by local conditions of finance, rates, and laws governing the management of such utilities.

Mr. A. A. Reimer: The paper presented by Mr. Reed impressed the speaker as being well worthy of study, and he was sorry it had not been presented in time to be printed in the March Proceedings, so that we could have studied it more; such a paper requires considerable thought. Our principal object in speaking at this time is to ask if we cannot have copies of that prepared and sent to those at least who have taken part in the discussion today, so that we can extend our discussions along other lines, if that is practicable.

Mr. J. M. Diven: Under our present system of publication, the papers after being published are still subject to discussion, the discussion to be printed in a subsequent issue of the Journal. That is one of the advantages of the present system as compared with the old.

Mr. A. A. Reimer: The speaker will be glad to study the paper more carefully. The remarks made by Mr. Wills show that other places are using modifications of the general scheme after taking the money from the property owners temporarily. Now we had that plan to some extent, but never pushed it very much. We made a modification, however, that any person wishing an extension in a newly developed property, or a property that was on the map to be developed, would have to guarantee us a certain revenue. We were willing to pay the money for the work and capitalize it, of course, but we wanted to see a guarantee of a certain revenue that would meet a given percentage of the cost before we were willing to go ahead with the work. The result of that has been to prevent a great many wildcat schemes, and today an operator who wants to develop truck land counts his cost before he goes into it instead of having the city pay all the bills.

Mr. William Luscombe: Will Mr. Reimer be more specific as to what that given percentage is?

Mr. A. A. Reimer: In our case we call for 10 per cent of the guaranteed revenue. Then, if the promoter does not build a house along

that main and we get no water revenue, we are sure of at least 10 per cent on the cost. If he does not build any houses, he has to pay us 10 per cent anyhow.

Mr. Theodore A. Leisen: The speaker has not anything special to say except that it might be interesting to state another instance of how such assessments are made. In Detroit for some years past the policy has been to make extensions wherever buildings are going up, on what is termed a "bonus" plan, the estimated cost of the pipe line being figured out, a bonus of 15 per cent per annum is charged, being supposed to be based on 5 per cent interest on the investment for three years, with the expectation that at the end of three years there will be enough built-up property to make it a paying proposition. The consumer is credited with whatever revenue may be derived from the water supply that is provided for the property at the time the main is laid, and the revenue so credited is deducted from the 15 per cent, the difference being the bonus which he has to pay.

President Earl: Your chairman was very much interested in this paper. Its statement indicating that the New Orleans water rates make no provision for vacant or unimproved property or other interests which are benefited by the water supply, but do not use water to participate in a fair proportion of payment for the benefits which they receive, is in error. The New Orleans rate, and the advocacy of the speaker's paper on water rates, tend very strongly toward a full participation by the taxpayer, as a taxpayer, for all of the benefits which he receives as a taxpayer. This is the very essence of a fair water rate for rate payers, because if any interest which is benefited escapes its fair share of payment, it is inevitable that some other interests or persons must pay an unfairly large proportion to cover the deficit.

There are so many conditions of law under which water works projects have to be financed, that it is a difficult problem to work out a fair distribution of costs and system of reimbursements to cover costs of extension, and also to arrive at a fair division of water rates, and still comply with existing legal restrictions.

Mr. Reed's paper advocates a plan for proportioning the cost of water works extensions, and arranging reimbursements, which appears to be equitable, under those conditions of law governing the financing of extensions which will permit of its adoption. This plan

relieves the water works from carrying unproductive property in extensions until they become reasonably productive, and places the burden of widely scattered extensions in sparsely built areas upon those who are benefited by them until the water consumption reaches a stage where the extension is fully warranted.

These are matters in which your chairman has taken a very deep interest, and which he believes are susceptible of formulation into a general system of financing, both for construction costs and costs of extensions and reimbursements therefor, and also of determining a division between the taxpayers' and the rate payers' fair share of the burden of maintenance and operation, including fixed charges, and finally of fixing the rate as between rate payers, so that all along the line these burdens will be equitably distributed, i.e., to say so that each taxpayer and each rate payer will bear his fair share of cost for each item of service which he receives, paying as a taxpayer for the benefits which accrue to all taxpayers, whether they are water consumers and rate payers or not, and as a rate payer for the benefits which accrue to water consumers only, and paying in proportion to his consumption for the items which vary in cost in proportion to consumption, and in proportion to the size of his service and meter for the items which vary in cost mainly in proportion to said size.

Several papers read before this Association within the last few years, including Mr. Reed's, just presented, contain matter of the greatest value, looking toward the formulation of such a scheme, and your chairman wishes a little later, as a member of the Association, to assist in presenting some further studies in these connections, with the hope that they may be of assistance in reaching something fairer and more uniform in the treatment of these questions than is shown in the widely varying general practice of today, and will be glad if the Association eventually can see its way to the endorsement of some general system of solution of these problems which would tend toward fairness and uniformity therein.

Mr. Francis C. Hersey, Jr.: There was a case in Wellesley this last year where a promoter laid out a remote section of the town principally in small bungalow lots for summer homes, etc. You know how these propositions as a rule pan out. For three or four years everything looks prosperous, then perhaps interest dies out and the whole thing goes to pieces. They wanted water and we esti-

mated it would cost us $3000 to lay a 6-inch main into this property. We got the promoters to give us a surety company's bond for $3000, guaranteeing that in case in any one of the five years the bond is to run the amount of water used (all metered) did not equal $600, they would pay us the difference. If at the end of five years the development was a failure we would come out practically even on cost of extensions. If it was a success, we would be ahead.

Mr. A. A. Reimer: The speaker takes somewhat the same attitude that the last speaker has expressed and in which others of the speakers seemed to concur, that the promoter has everything to win and nothing to lose. If they go into this game on their own basis we stand to lose, not to gain. Take the last case cited, having served water up to the limit of five years, how much was he in? We have to be very careful, if we adopt any of these plans, to see that we protect our city or our company, in case it is a private company, so that the time will not come when a heavy investment literally sinks into the ground and leaves a hole in our finances. Even if we get rentals for five years, we are out the water anyway.

Mr. Frank C. Kimball: It may be of some interest to state that, without laying down a formal rule to be applied in all cases, the Public Utility Commission of New Jersey have recommended in several instances that water and gas utilities make extensions of their piping systems for reasonable distances whenever the owner of the property to be benefited thereby will guarantee a return of 10 cents per foot per year upon all pipe so laid, for a term of five years.

Mr. J. M. Diven: Most new land developments are more or less of a gamble and to leave the chance element all to the promoters the speaker has used the following method, considering that it is no part of the duty of a water department or company to go into gambling schemes; the promoters are required to pay all cost of pipe extensions into the property, including valves, fire hydrants, services, etc., with an agreement on the part of the department or company that it will refund the cost of the construction and take over the mains and appliances as soon as a certain number of houses have been erected, connected with the mains and commence paying a revenue, or when a certain specified income is received from the extension. Some portion of the capital furnished for the extension may be returned to

the promotors when a less number of houses than the full specified number are built and using water, or when a revenue somewhat less than a full paying one is received, but the contracts generally require the full number of water takers or amount of annual revenue before the mains are taken over and paid for. No interest on the cost is provided for in these contracts, the promoters standing that much as a part of their gamble.

By this method no money is advanced or invested by the water department or company until the development has proven a success and a paying investment for the water works.

Mr. D. A. Reed: Replying to some of the questions that have been asked; the paper refers more particularly to a municipal plant and still more particularly to the question of the establishing of equitable rates based upon actual cost, not only of the water supplied but the cost of extensions, it being the theory that the extensions should be assessable as nearly as practicable against the abutting property, and that the cost of operating should be borne by the customers using the water.

The question has often come up in our cities, how to make extensions in the streets where the people are not able to advance the money, as was stated by the first speaker. We often find that to be the case even under the present system. Our system embraces the idea that the utility itself should advance the money for extensions out of the depreciation, reserve and sinking funds or any other funds it may have available—temporarily. If money is used to make such extensions the property owners have the privilege of paying all that back into those funds at once if they wish; if not, 8 per cent is assessed yearly against abutting property, the idea being that the 8 per cent will eventually return all the money to those funds. It seems to the speaker unfair to make an extension under a straight guarantee system of either 8 or 10 or any other per cent. When extensions are first put in there are no customers. One extension made last year costing $9000 had no consumers; there was not a house on the extension. As the consumption increases the total water rates will be deducted from that 8 per cent each year, so that at the time the total revenue exactly equals 8 per cent, the guarantee would be discontinued, and we would be getting only about half that amount because the other half of the 8 per cent would go to operating expense; in fact, in some portions of the system it would

cost much more than the total guarantee to operate, to say nothing of the fixed charges. For that reason this particular feature that the writer attempted to describe embraces the idea of crediting on the guarantee or assessment, by whichever name you call it, sometimes it is called a "guarantee" and it is sometimes called an "assessment," only that portion of the revenues which applies to capital investment. The balance of the water rates not credited to the frontage assessment goes to pay operating expenses as it should. If a man owns a 50-foot lot and his water rate is \$6 a year, one-half or \$3 is credited against the \$4 assessment that is placed against that property, leaving \$1 to be paid in cash. If he is using gas, one-third of his gas rate also is credited, the idea being that the half or one-third of the amount which he pays goes to pay the interest on capital investment of the entire plant. Generally a man's water and gas consumption wipes out his entire assessment. A vacant lot however continues to pay in cash the full assessment until enough consumers have been added to release the entire assessment. We have one section of the city that costs us over fifteen cents per one hundred cubic feet to furnish water. Under the old system of the straight 8 per cent guarantee the department or utility gets its money back when there is nobody using water. Up to the time, or nearly the time, when they were using enough water to retire the guarantee, we were losing money; and when the guarantee was discontinued, we were losing still more money for the reason that we had lost our 8 per cent returns on the investment and were furnishing water at about one-third its actual cost.

The speaker will be very glad indeed to have a full discussion of this subject. It is somewhat different from any system that has come to his notice but seems to have worked itself out automatically.

WATER FROM GRAVEL WELLS

C. W. Wiles[1]

The water supply of the Delaware Water Company, Delaware, Ohio, is obtained from rock and gravel wells, three miles north of the city, in a bend of the Olentangy River, covering an area of about 25 acres.

In 1909 an additional supply under the direction of H. F. Dunham, C.E., was obtained by running a suction line about 75 to 100 feet from the river, following its contour for a distance of about 1400 feet. On this line was constructed three deep rock wells, and thirteen gravel wells, the latter being 4-inch with 3 to 4-foot strainers, at an average depth of 28 feet.

During the dry summer of 1914 an additional supply was thought necessary and plans made for additional wells. A new suction line was laid at right angles to the old one, and connected to it with a 10-inch cast iron pipe, and 6 new wells were drilled in the open field some 400 feet from the old line of wells. In this location we found 2 or 3 feet of soil, 12 feet of sand, mixed with some gravel and small boulders, and 12 feet of coarse water bearing gravel. It was evident that at some time, this bend in the river had been its bed.

With a well drilling outfit the new 6-inch galvanized casings were sunk to the rock at an average depth of 28 feet, then the casing withdrawn about 3 feet and a small charge of dynamite exploded at the bottom, after which the gravel was taken out and the casing carried down to rock again. A 6-foot strainer was placed inside the casing at the bottom, and held in place while the casing was withdrawn to near the top of the strainer, and a lead seal swedged to the top of the strainer. With a gasoline engine and small pump, the wells were pumped for 24 to 48 hours, until all sediment was taken out, and the water clear. These wells with the small pump showed a discharge of over 100,000 gallons each in 24 hours.

In order to reach the same level as the original suction line, it was necessary to place the suction line for these walls 12 to 14

[1] Superintendent Water Works, Delaware, Ohio.

feet deep, this being just above the water line, at a time when the ground water was the lowest known in years. This gave promise of an abundant supply. These wells were then connected to the suction line, with a gate valve to each well to facilitate cleaning when necessary. During the low period of ground water we found that air was being taken into the suction, and some trouble was experienced with the pumps, and considerable inquiry by water consumers as to what we were putting in the water that made it look like milk.

A test of the main suction line was made by shutting off all wells, and an air pressure of 90 pounds placed on it, without any loss for several hours, showing that the air must come from some of the old wells put in in 1909. All these wells on being uncapped showed from 2 to 6 feet of water above the strainers. The only probable solution of the air trouble we could find was that when the wells were in use under suction the water level in the wells was drawn down below the top of the strainers at times, admitting air; and this must have been caused by the partial stoppage of the strainers, or a general low condition of water in the surrounding gravel. We found upon test that no air came from the new wells, the water level in these being 6 to 8 feet above the top of the strainers.

Some engineers having experience with this system of wells have suggested that our 4-inch wells are entirely too small, and that all such wells should be not less than 6 inches in diameter, but rather should have been 8 to 10 inches, with no strainers when in water bearing gravel, but should have perforations or holes in the bottom of the casing equal to one and one-half times the area of the pipe. Then instead of drawing the water from the body of the well, a smaller suction to be dropped inside the outer casing, well to the bottom, and connected to the suction. This would obviate the trouble of air finding its way through the top part of the strainer, and allow the well to operate until nearly exhausted.

This paper is presented for your consideration, with a view of bringing out suggestions of the best method of constructing wells in gravel.

DISCUSSION

Mr. C. W. Wiles: Mr. Chairman and Gentlemen, many of you do not rely on gravel for the water supply; but those who do know that it is a very important matter to know how to get water out of the gravel into the pump. The paper is simply a rehash of our sys-

tem of taking water from gravel, and it will interest possibly those who are similarly situated.

Mr. W. J. Haddow: The city of Brantford, a Canadian city, draws all of its water from gravel bar soil, using a different method altogether from that described by the writer of the paper. We have a long collecting gallery made of perforated tile pipe laid corresponding with the contour of the river, and the water flows down through it into a large concrete well. In case of low water we have an arrangement by which we can admit water from the river and cause it to flow to a central well from which it is distributed in various directions so that it will fall into this collecting gallery. By thus flooding the soil we obviate the low water difficulty.

Mr. W. E. Haseltine: We get our water from gravel. We have found in our case that we do not have to go more than 15 or 18 feet for it; it is comparatively near the surface. We have dug down to a depth of 15 to 18 feet and constructed a gallery similar to the gallery mentioned by the last speaker. The walls are laid with rock and reinforced with concrete cap. The water is carried from there into the well which is also located in the gravel, and the water is pumped from that. We, of course, have no trouble of the kind referred to by the gentleman who read the paper.

Mr. John W. Moore: Throughout a large part of Indiana it is found desirable to tap the water bearing gravel stratum and also the underlying water bearing limestone stratum with the same well. One of the methods by which this combination well is successfully constructed is as follows: Assuming that the finished well shall be 10 inches in diameter, first a drive pipe 12 inches in diameter is sunk to rock, the depth and thickness of the water bearing gravel strata being carefully noted. A 10-inch diameter hole is then drilled to the desired depth into the water-bearing rock. A 10-inch diameter pipe is then lowered inside the 12-inch drive pipe and seated on the rock. One or more screens, 10 inches in diameter are made up and form a part of this 10-inch pipe, the screens being located so that they will come opposite the several water-bearing gravel strata. The 12-inch drive pipe is then pulled, which allows the water from the gravel to enter the well. In designing air lift pumping systems the writer has also used this method to secure the proper submergence.

Mr. H. C. Hodgkins: There is a gentleman here who comes down from a district where they have the finest farms, and the population is largely German, even in larger percentage than here in Cincinnati. He is taking water from wells in a very unique way. The speaker would like to call on Mr. Hymmen, of Berlin, Ontario.

Mr. H. Hymmen: We have altogether about fifteen wells that we are using. Some of them are pumped by compressed air. We have started to use turbine pumps, direct connected, electric drive, which are giving us very good results. We had air on at first. When we first put in our air plant we pumped out sand and filled up our conduit. We then put on a small turbine pump, a 3-inch suction electric drive turbine pump, direct connected. We are getting 75,000 gallons in 24 hours. Some of these wells have 20 feet suction, and some 30 feet suction. They are down 32 feet in the well.

CITY FIRE LIMITS

By Albert Blauvelt

This is not a set talk, and if any one can enliven the occasion by any question or remarks the speaker will be glad to have him do so.

A water works is of course an essential of modern fire protection, yet it is but one of twelve general factors or departments which go to make up the fire protection of a large city as a whole. One also of the twelve parts or factors of modern city fire protection is the "fire limits" or central district in which frame buildings are prohibited. This evening's talk is to attempt to show that our cities in general are more in need of higher requirements as to the fire limits, than of high pressure systems or larger water works.

The public usually gets its idea of the presence of the water supply by seeing fire department hose streams. At time of disastrous fire the unfortunate practical fact is that such a fire is usually so large that it becomes a dry fire, one which does not receive any water at its heart, or core, and to that extent the water works is useless. Any one who is in the least accustomed to examining fire ruins can very readily tell whether water reached the heart or center of the fire, or whether the fire remained dry, and it is an unfortunate fact that the important fires are ofttimes dry at the center or precisely where water would do most good were it possible to apply it. Another still more unfortunate fact is that the bigger a fire, the more certain it is to be a fire which may be termed a dry fire. That is peculiarly a characteristic of all very heavy city fires after the hot blast has developed.

The conflagration of the city of Chicago in 1871 was such, and typical of the most destructive type of conflagration, and is especially interesting in connection with the particular viewpoint that we will come to later.

When Chicago had its great fire the city then had but about 350,000 inhabitants. While that fire originated at a point which is now inside the fire limits, yet the fire of 1871 was typical in its day as an outskirts fire and from that outlying place of origin burned into and through the city proper.

Another of the older of the modern city fires, that at Boston in 1872, was typical of another type of conflagration which begins in the heart of the city, and in the teeth of the fire department, then goes on and develops into the conflagration form.

Toronto has had several severe fires mostly starting in some cheap district where special fire protection would be a financial impossibility.

The Baltimore conflagration was carefully analyzed by men who had studied earlier conflagrations, and is more accurately mapped and platted than any other conflagration. It began in the face of the fire department, in the heart of the city, with no high wind, no severe weather, everything favorable for fire department operations, with lavish supply from the water department, and in broad early daylight. The wind during the whole period of that fire was very moderate as shown by the United States Weather Bureau, and yet, if that wind had not shifted toward the bay or harbor there would have been little left of Baltimore. These typical examples of very heavy and disastrous city fires, some of which started in town and some out of town, were dry fires each and all.

We are often indebted to our newspaper friends for some acute observations, for instance, the *Chicago Tribune*, with reference to the Baltimore fire, has this to say:

> It was a great fire, and a peculiar one, in that it was a dry fire, that is to say, not a quart of water reached the central portion of the conflagration. The temperature of the fire that beat against and into the skyscrapers was probably 2000°. It was a terrible assault. The unprotected window openings afforded easy ingress to the fire, and plenty of woodwork was found on the inside for the flames to feed upon.

This *Tribune* report was absolutely accurate and we must also remember that the Baltimore fire was no more dry than preceding conflagrations all have been and to a certain extent must ever be.

Another thing that is misleading, although it is extremely natural, but it is unfortunate, is that we habitually speak of the burning of buildings. Now buildings do not comprise a city. A city is composed of contents, and the buildings are merely accessory to the contents. It is the contents that ignite, it is the contents that represent the bulk of values and fuel. We may say that the spectacle or phenomenon of a conflagration should be looked upon not as one building burning another, but as the contents of one building communicating the fire to contents of the next building. The contents

are the important things, both as to the hazard, the quantity or bulk of combustible material, and the value.

At Baltimore the steel frames that stood after the fire were simply rough shells of what were formerly buildings and their contents. Some people imagine that those frames represented a considerable salvage. Unfortunately they represented very little salvage as compared to original values plus tenants' property. The people who occupy office buildings have a great deal more property as tenants than they themselves know, anywhere from $50,000 to $150,000 per floor is not at all uncommon. The burning at Baltimore was not so much from building to building as from contents to contents; and the prime cause of the destruction of the so-called fireproof buildings was not the general fire but the contents of said buildings, however slight those contents might appear.

When you use steam boilers, you expect a pound of fuel to evaporate about ten pounds of water. When you burn a pound of fuel in a foundry cupola you expect it to reduce far more than its own weight of metal, and the same rule that applies to the ordinary furnace equally applies to the destructive or reducing power of fuel inside a building. The Continental Trust Company Building at Baltimore is a case in point. This was a bank underneath an exclusive office building. The contents were simply ordinary desks and furniture, trim, office files and so on, which one would hardly think of as sufficient fuel to reduce all to a gaunt skeleton, yet the destruction was brought about mainly from the mere contents.

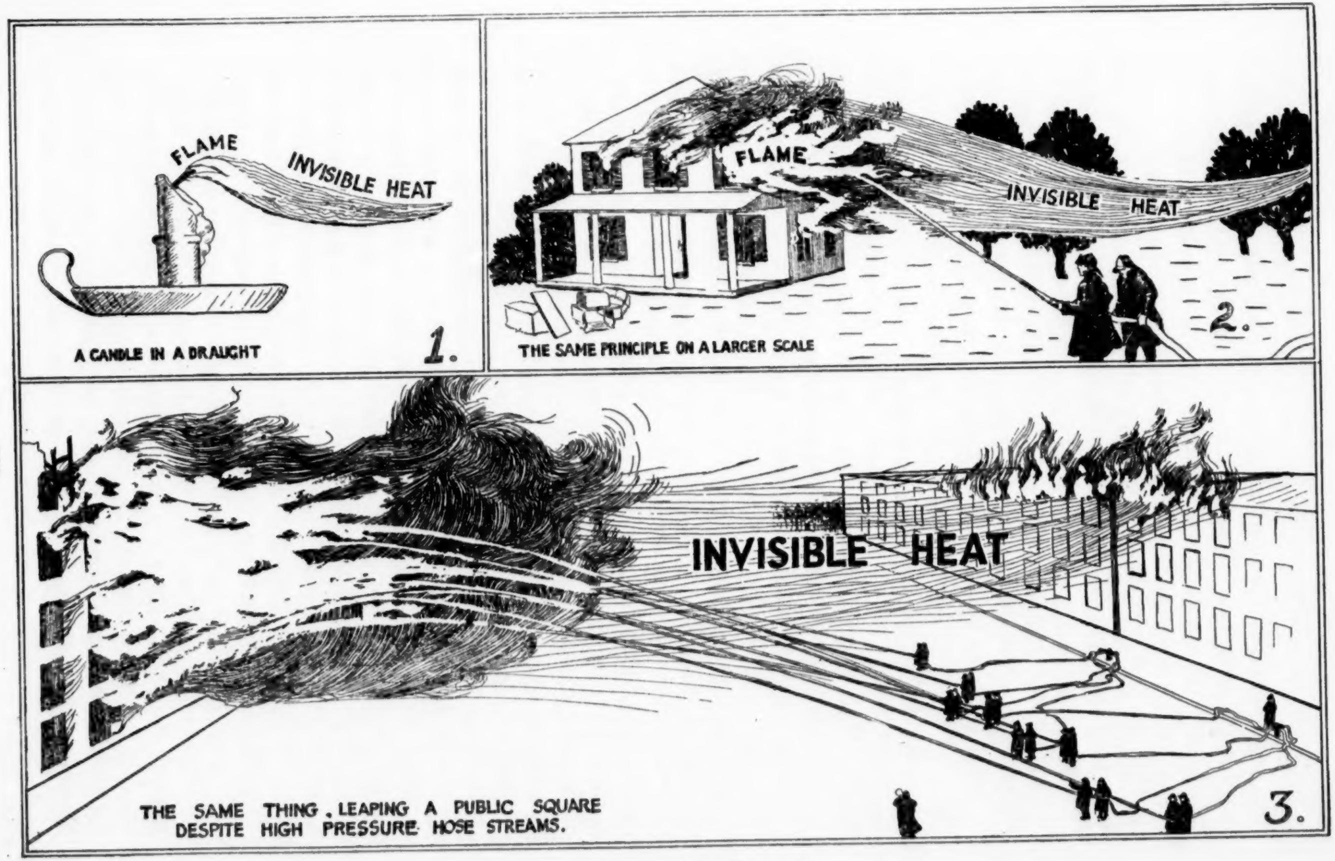
It may seem unreasonable to state that a fire can be dry with the fire department at work, and considering that Baltimore had lavish water works. That is a perfectly pertinent question respecting all heavy city fires, with the fire department in operation, and the water works also in full operation, and, if so, why have either? The answer is that had it not been for the water works, and had it not been for the fire department, the fire at Baltimore would have reached enormously greater dimensions than it did. The fire departments were not able to do anything at all in the direct central path of the fire, but local and visiting firemen did an immense amount of good in hemming in the edges and so preventing the fire from cutting a much wider swath, and also did an immense service in checking fire from fire brands which were thrown far in advance of the main fire.

Why it is that these heavy fires get no water where most needed is something which many of you already appreciate yet it may not

be amiss to try an explanation of it. The principle is a simple one. Let anyone hold the hand over the flame of a candle. You will find that the heat is not bearable to the hand even at a considerable distance when held directly over the flame. It is also noticeable that there is a strong upward draft although the air in the room may be quiet. In any fire the expansion of gases due to the combustion speeds up the draft and we can calculate the velocity of the draught of a large fire from the manner in which it is able to throw firebrands. In a rough way it is a fair statement that the acceleration of draft local to, and immediately proceeding from, a fire is about four to one. That is to say, a 10-mile breeze fanning a fire is accelerated into about a 40-mile wind as it issues from that fire; and a 25-mile wind supplying oxygen to a great fire will accelerate up to approximately 100 miles an hour as it comes out of the fire. All this is consistent with the action of a large fire as to its throwing heavy firebrands to great heights and long distances. It does not take a very large fire to produce a dangerous hot blast and if the wind is sufficient to carry this hot blast over into a fairly horizontal position, the firemen are then held at a distance and cannot endure the hot blast and must retreat. The rear or trail of the fire necessarily is a bed or trail of burning embers. The fire department cannot work on the front or rear of a great fire simply because the hot blast occupies the front and an area of burning ruins occupies the rear.

Illustration No. 1 is intended to show the action of the hot blast as if it were visible. Any one who will take a slow speed fan and set a candle in front of it, will find it impossible to hold the hand close to that candle sidewise as is natural because the heat is then carried to the side. A house fire in a wind acts the same except, as is illustrated, it is on a larger scale. In small fires like a single house a hose stream is long enough to overreach the hot blast. But when the fire is a large one and fanned by a brisk wind, as shown in the main or lower figure of the illustration, it makes no difference how powerful the hose stream is, no hose stream can overreach the length nor the diagonal width of the hot blast and, therefore, the core or heart of the fire remains dry.

At Baltimore the wind did not at any time exceed twenty-five miles an hour; but there were times in certain streets when firemen could not stand within several hundred feet of the front of that fire. The hose streams were absolutely ridiculous and such is the situation in all large fires in a wind; the hot blast makes it impossible for



Action of Hot Blasts

the firemen to hold a front stand to head off the fire. Such fires have never been controlled by any water works or any fire department, and from the nature of the case they burn a wide swath through a city unless the wind dies down. The Chicago fire simply burned on through into the lake. At Baltimore the fire burned out to the harbor. At Lynn, Massachusetts, it burned out to the Atlantic Ocean.

Coming to the question as to whether these hot blast fires can be prevented, or whether we must expect to have more cities wrecked, it seems certain that there is no complete remedy and yet there is at least a seven-eighths remedy. In the outskirts of cities no human ingenuity can suggest a remedy that is within financial bounds. A fire may come from this, that, or the other cause on the outskirts where cheap property cannot bear the cost of any effective anti-conflagration treatment. There is, however, a great deal of ground for believing that the very costly central districts of a city can be protected in spite of a conflagration that comes in from the outskirts, and that it is also possible to so protect the central or costly district that a conflagration cannot arise within said district. Experience has shown that a number of heavy city fires after having gone wholly out of control have later been gotten under control because of reaching a location presenting the resistance of shuttered alleys. A thoroughly shuttered alley exercises a great slowing-up effect. Any fire on reaching a full set of shutters or wired glass is checked considerably and is checked further in crossing the alley and checked again severely by the second set of shutters or wired glass. This is not to say any two sets of window stops will stop any such heavy fire as at Baltimore; but the point is that merely a plain alley thoroughly stopped on two sides has checked some fires which were wholly beyond fire department control and points to general use of protected windows. Many fire protection engineers believe that to protect the window openings of the central district of a city would alone be sufficient as an anti-conflagration treatment. The thing needful is to prevent fire inside a building from coming out of that building, and thus keep the fire from reaching the contents of the adjacent building. Fires are fed by the interior contents of buildings. If fire originates in a building or enters a building on the windward side the thing essential is to prevent the fire escaping and spreading from out the down wind or lee side. Obviously a street main, however large, is not able to help us in this particular, after a hot blast has developed and the firemen are unable to hold ground.

Now, there have been some very interesting experiences that prove that this fatal communication from contents to contents does not necessarily have to be guarded against by fire walls nor by shutters or wired glass. It has been found that spread of fire from contents to contents can be checked by a spray as from automatic sprinklers. In fact, a dense spray seems more effective than a fire wall provided the spray is deep, perhaps if need be, as deep as the building.

The city of Boston in 1893 had a fire which was absolutely beyond the control of the fire department until checked by a sprinklered building, known as the Brown-Durell Building, a very large brick building which stood directly in the path of the brunt of the hot blast. The heat opened a large number of sprinklers and the hot blast was sufficiently absorbed by the volume of spray and that hot blast did not emerge on the lee side of the building and the town was saved. Another sprinklered building, the Kilgour, is also credited by good judges as having been of similar service in Toronto in 1904. The spray must be deep, must be backed by a large water supply and must be inside, not on the outside, of the building, because outside spray blows out of place and away in a wind such as always exists at a time of conflagration.

As earlier stated, cheap property cannot stand the expense of preparation to positively stop the spread and run of fire, but it is commercial and also possible to prepare a costly congested district to do so and also to stand the brunt of any fire from a cheap district. This means the establishment of special fire limits inside of the ordinary fire limits, using waterless sprinklers and fire department engine water for some buildings, protected windows on other buildings, automatic water supply sprinklers in other buildings, etc., always keeping in mind the principle of intercepting the communication of fire from contents to contents. Such protective features because of cost would be mostly limited to a four-story or higher district or to city values aggregating not less than $100,000,000 per square mile.

The fire that attacked the Brown-Durell Building was burning up values at the rate of $800,000,000 per square mile, and in such a district an inner fire limits would be cheap in relation to the risk and the values at stake. A city carries about nine-tenths of its values upon about one-tenth of its area. Experience with those few very heavy city fires that have been checked has shown very conclusively that they cannot be stopped at any exact dead line but can be stopped within one or at the most two blocks as shown on the illustration.

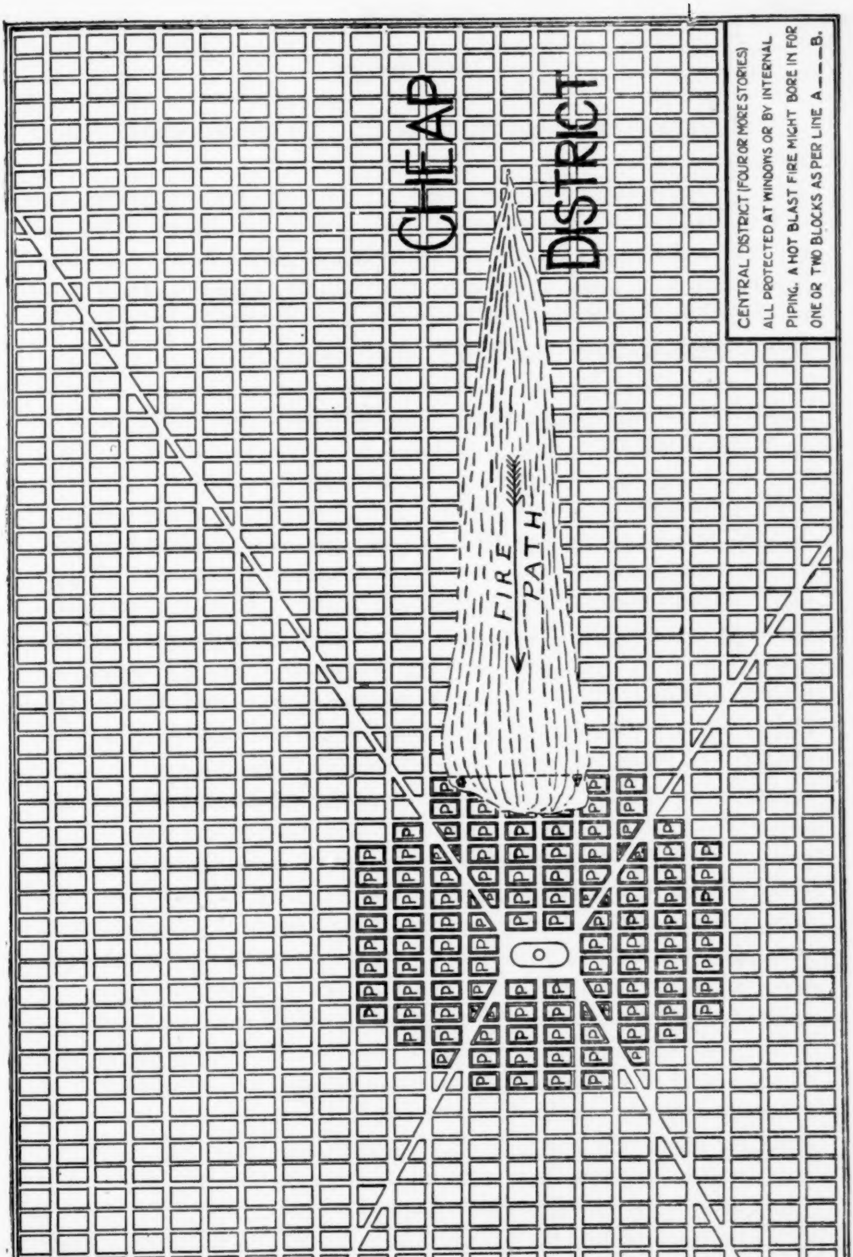
Because firemen cannot stand against a hot blast longer than the length of a hose stream, we cannot, therefore, through firemen or through water works expect to make safe our large city values. But we can establish an inner fire limit wherein the hot blast would either be deflected by successive barriers or be absorbed by spray, or partly deflected and partly absorbed, so that the fire shall subside sufficiently to permit the normal operation of the fire department and be within the capacity of the average water works.

The second illustration shows an inner fire limit (the group of blocks marked "P"), indicating a district in which every building is piped for sprinklers or, if not, has protected windows on all sides.

It seems to the speaker that our big cities can spend money to far better advantage to deflect or absorb hot blast fires from driving through their central districts than for heavier water mains or larger fire departments. It makes no difference what pressure may be used nor what water is provided as against the fact that no water works nor fire department can cope with a well developed hot blast. Better to agitate for checking the hot blast rather than expect the impossible from the fire department or the water works.

An inner fire limit as described is not likely to be put into practice at any very early date; the difficulty of apportioning the expense is very great. It involves the necessity for coercing the property owners as to their individual properties, and there are many such reasons which probably will for a very long time prevent our large cities from establishing inner fire limits to resist attack of a hot blast from a cheap district; and yet conviction seems unescapable that eventually something of that kind must be done. Our cities are growing and the values are piling up. We have never had any true hot blast checked by any fire department or water department, and we cannot have. We also have never had a really big fire yet as compared to the chances in our great cities. These conflagrations lie in wait for our big cities, and ordinary arithmetic indicates that some of these fine mornings we will wake up and find some city of a million inhabitants wiped out and with it a realization will come that a very small percentage of such an appalling loss if applied to central protection would have protected all of the larger cities and also paid its way on a yearly fire basis.

In this problem of city fire protection the real need is on the part of the citizens of the town and the individual building owners to rearrange the city plan proper.


CHEAP DISTRICT
FIRE PATH
CENTRAL DISTRICT (FOUR OR MORE STORIES)
ALL PROTECTED AT WINDOWS OR BY INTERNAL
PIPING. A HOT BLAST FIRE MIGHT BORE IN FOR
ONE OR TWO BLOCKS AS PER LINE A___B.

DISCUSSION

A Member: How about water curtains; are they effectual in stopping fires?

Mr. Blauvelt: Water curtains are not of very much good except for a moderate fire. When there is a constant heavy fire blast bearing on a building a depth of spray about as deep as from here to the other side of the hall is needed and this can only be had in sprinklered buildings with heavy water supply.

A Member: About the Salem fire; was that a fire which came in from the cheap district?

Mr. Blauvelt: Yes, sir; started out in the thinly settled district and burned down into the town. A city like Salem, however, could not be protected by any engineering short of reconstruction. What has been said must apply to fire limits inside of what is now recognized as modern fire limits. An inner fire limit as discussed is applicable only inside of what are now known as "fire limit districts" in which shingle roofs and frame buildings have been eliminated. Salem was a town of much frame and shingle roofs, and there are no engineering plans that might meet that situation.

ARTESIAN WELLS AND METHODS OF PUMPING THEM

By John D. Kilpatrick

NECESSITY FOR WATER SUPPLY FROM UNDERGROUND SOURCES

During the several years the speaker has been attending these conventions, he has observed that the papers and discussions on water supplies have been confined, in a great measure, to the treatment of water obtained from surface sources. These discussions have gone into considerable detail regarding the proper design and construction of filter plants, the design, construction and operation of filter beds, and a number of papers have been read on the proper method of still further destroying injurious bacteria which may have escaped elimination in the filter beds. But, there has not been much discussion on the subject of the design, construction and operation of water supplies obtained from underground sources, particularly those from driven wells.

In a great many localities the underlying formation is such that a water supply from a driven well system is impossible to obtain, but there are hundreds of municipalities where it is possible to obtain an artesian supply and consideration should be given to this source, even when a filtration plant is available.

A great point has been made in the discussions before this Association and also in reports of consulting engineers that artesian supplies are not permanent in character. The writer disputes this point, because his experience, extending over a great many years, has led him to believe that the fault is not with the underlying water bearing strata, but either with the construction of the wells themselves or to bad condition, due to neglect. It would be folly to generalize to the extent of saying that it is possible to draw an unlimited quantity of water from any given water bearing strata any more than the statement might be made that an unlimited quantity of water can be obtained from any surface stream, but there are many cases where the yield from the wells has steadily fallen off and where it was possible, by developing the wells and possibly changing the methods of pumping, to bring the wells back to their original and sometimes to

an even greater yield. For example, the wells of Montgomery, Alabama, which gave some years ago about 5,000,000 gallons of water per day had dropped off until it was possible to obtain only 4,000,000 gallons per day. By cleaning out the strainers and developing the wells, and by this latter term is meant cleaning out the fine sand which had collected in the region surrounding the strainers, and installing a more efficient type of air-lift, these wells were brought up to yield approximately 5,500,000 gallons per day. This was in a sand formation. A number of similar instances could be cited, but lack of time will not permit. The writer refers particularly to wells driven through sand or gravel formation where the use of a strainer is necessary. Of course, in the case of wells driven into the rock, it is only possible to obtain from any rock hole the amount of water contained or flowing through the crevices and fissures in the rock. With sand holes, however, the yield from any well is greatly affected by methods of construction and development of the well when drilled. The writer has drilled wells that yielded 15 gallons per minute which have been brought up to over 300 gallons per minute before being put into service.

In locations where there is a choice between artesian well water and a surface water supply that has to be filtered before it is possible for the water to be used, more consideration should be given to an artesian supply if the cost of the plant and the cost of water delivered to the pressure pumps is close enough to allow of debate. This opinion is based solely on the ground of the purity of the supply. After hearing the many interesting papers that have been read at these conventions on the subject of filtration for large municipal supplies, the writer realizes that there is a tremendous field for filtration and that it has solved the problem of water supply for a great many cities in this country and abroad; and further that for the larger cities in this country an artesian supply which has to be pumped to the surface of the ground is, in a great many cases, entirely out of the question.

The writer refers particularly to the purity of supplies from driven wells and admits at the same time that driven well water in almost every case is harder water than that obtained from surface streams. In very few cases, however, does driven well water have to be treated either to clarify or purify it. The installation of a filter plant for the clarification of a surface supply is not the end of that problem; ceaseless vigilance in the care of the filter is the only price of safety.

There are localities where it is debatable whether an artesian supply is better and more economical to operate than a supply taken from a surface stream that is to be filtered, and still other localities where there are no surface streams and the municipality is compelled to resort to artesian wells.

The problems involved in the laying out of an artesian well system may be grouped under three heads:

1. Location of the wells.
2. Methods of drilling and construction.
3. Methods of pumping.

No consideration will be given in this paper to the methods of pumping from the pump house up to the storage reservoir, nor to distribution systems. Only the delivery of the water to the suction basin in connection with the main pumps will be treated.

LOCATION OF THE WELLS

The location of the wells depends upon the extent and surface conditions of the land available for the well field. No rules can be set down for the proper location of wells until test wells have been drilled, unless the underlying conditions are known from wells in the vicinity. In laying out a pumping plant which will obtain the supply from wells, as a general rule, it is best to drill the wells and locate the pump on the lowest possible ground available. The obvious reason for this is that in drilling the wells we penetrate to the underground stream and the object is to have the pumped level of the water as close to the surface as possible, because as a general rule it is more expensive per foot of pump head to deliver the water to the surface of the ground than from the surface reservoir up to the storage tank. If the well field is to be in a well defined valley, it is preferable to drill the wells in a line across rather than parallel with the direction of the valley, because the underground stream of water may flow in the same general direction as the surface streams. This, however, is not always the case, and before locating definitely any number of wells, it is advisable to drill test wells at various points. There have been cases where city councils have taken the matter into their own hands and have drilled wells on the summit of the hill on which they have decided to place the storage reservoir under the specious reasoning that if they could get a flowing well in the valley, they should get on top of the hill a flowing well delivering its water freely into the storage reservoir, which would save the ex-

pense of pumping. Unfortunately, water will not rise above its source and the money spent on drilling these altitudinous wells has been thrown away. There are places where it is possible to obtain flowing wells on the summits of high hills, but they are the exceptions which merely prove the rule.

In regard to the location of underground water supplies by the use of forked sticks, magnetic balls, pendulums, indicators for radio activity and other devices, the belief in such occult means is only evidence of the survival of a superstition of the alchemist's age. The writer has known some of the most famous of these so-called "dousers," but has never yet been able to pin them down to statements which they were willing to back up by a bond.

This afternoon the speaker went out into the country and cut a couple of forked sticks; whether these forked sticks are from peach trees, witch-hazel bushes or not, is immaterial. Placing this glass of water on the floor you will note that when one branch of the fork is grasped with the right hand and the other with the left, in walking over the glass of water the stem of the fork dips. You note that the dip takes place. Now, walking down the aisle you note that the stick dips again, showing that the presence of water has nothing whatever to do with the curious action of the stem of the twig. The explanation of this phenomenon is that it is only possible to operate a forked stick when the hands are held palms up. This position brings the little fingers of each hand on the inside. You will note after holding your hands with palms up, your fists tight together and gripping hard, that within a few seconds you will feel a strain on the muscles of the forearm which can be instantly relieved by releasing the grip of the little finger a trifle and possibly the third finger also. If you are holding the forks of a twig in your hands the release of the grip by the little finger and the third finger, together with an almost imperceptible turning of the fist downwards and inwards, will cause the stem of the twig to dip. This, accompanied by a releasing of the tension on the pro nator muscle that extends from the thumb side of the wrist diagonally across the forearm to the inside of the elbow, when the hands are held palms up, is the explanation of the dip. The mysterious action of the twig, therefore, is not influenced in any way by the action of subterranean water, but is due either to unconscious reflex action on the part of the operator, or is caused by "malice aforethought" on the part of the same worthy when he thinks he is in the neighbor-

hood of a favorable spot for the location of a well. The reason for the continued vogue of the uncanny action of the divining rod in the hands of these self-styled "water-finders" is due to the fact that the average citizen has a sneaking fondness for the occult; and when a "water-finder" makes good on the location of a well, the fact is advertised far and wide, and when he falls down, his failure is expected as a matter of course and is soon forgotten.

There have been a number of other methods used by "water-finders" that have come under the speaker's observation in the last twenty years. One of them, a Russian, had a mysterious box from which was suspended a pendulum. He would start this pendulum oscillating east and west and walk over a tract of land; and he claimed such mysterious power for himself and the pendulum that when he was vertically over the underground stream, the pendulum would stop oscillating east and west and swing in a northerly and southerly direction. At that point he would drive a stake; then he would start at the edge of the property again, a few yards further off, and walk in a parallel direction to his first line until the same change in the pendulum took place and then he would drive another stake. In this way he would plot out the direction of an underground stream. The violence with which the change in the swing of the pendulum took place would give him an idea of the depth. This scheme was all right and the Russian made a great many thousands of dollars out of it. No one, however, ever saw the box or the pendulum, which he concealed under a long and wide coat which he always wore. His compensation was based upon his demanding a fee of $100 for making what he called a "survey," and then getting a fee of $500 if his predictions came true. The old man generally arranged to go to the neighborhood of the tract two or three days before his formal survey and gather all the information he could about wells in the vicinity, and by taking differences in the level of the ground, he sometimes made very close guesses, and, as remarked before, you only heard about his successful surveys and never about his failures.

Another famous "douser" in New York asserted that he could feel the underground water in the ends of his fingers if he walked over the suspected territory with his arms outstretched. There was another one who had a box containing mysterious electric indicators by which he registered the radio activity of the underground water. This radio activity of the underground water acted in an opposite direction to the force of gravity and passed through concrete cellars,

flooring, the roofing and all other materials, so that it was just as easy for him to discover underground water from the roof of a ten story building, as it would be in the cellar of the same building. This man "got away with it" for three or four years, because, as we all know, there is one gullible person born every minute.

The only scientific method of determining the location for a well is to obtain all the information possible about wells in the vicinity together with all possible data regarding the underlying geological formations. A combination of experience with the aforesaid data and information is of considerable value. In addition to this information, test wells should be drilled to the maximum depth considered necessary and should not be less than 6 inches in diameter so that a pump of reasonable size can be installed and some conclusion drawn from the yield of the "prospect well." After these "prospect wells," the number of which will depend upon the local conditions, have been drilled and tested, sufficient data is at hand upon which to estimate the total number of wells that will have to be drilled to give the required yield. Great care must be taken to obtain an accurate record of all the formations passed through and frequent tests must be made to determine the yield at different depths.

METHODS OF DRILLING AND CONSTRUCTION

Driven wells may be roughly divided into two classes: (1) those where the water supply is obtained from the rock, and (2) those where the water bearing strata lie above the rock. A third class might be added, a combination of these two.

1. Where the rock lies at a short distance below the surface of the ground and the quality of the water above the rock is unsatisfactory, the pipe should be driven so as to seat firmly into the rock, shutting off the surface water. The most satisfactory method of doing this work in the case of the 8-inch finished hole in the rock, is to drive a 10-inch pipe down to the rock and drill a 10-inch hole in the rock far enough to be surely into the solid rock and below the shattered and seamy top surface. An 8-inch pipe should then be lowered to seat into the bottom of the 10-inch hole in the rock and cement grout poured in sufficiently to fill up the annular space around the 8-inch pipe in the 10-inch hole in the rock. After this is set and the 8-inch hole drilled on in the rock, the 10-inch pipe may be withdrawn for use in another well.

During the drilling of the well, tests should be made by means of

sand bucket or working barrel to determine the yield at different depths. A good indication of passing through water bearing crevices is the rise or fall of the standing water in the well. If continued drilling shows the same character of rock and the standing water level remains the same, it is a good indication that there is no great change in the possible yield of the well. Another indication of very little water in a rock well is shown by a great rise in the water level in the well when the drilling tools are lowered. When the well has reached the required depth, a test should be made, either with the working barrel, or the air-lift. If there are a number of wells to be put in, and the air-lift system is to be adopted for the permanent pumping plant, and the test is made with a working barrel, it is advisable to place the working barrel at a point below the surface so as to leave sufficient depth for the submergence of the air-lift. For instance, if the wells are 200 feet in depth, the writer would not recommend that the working barrel be placed more than 100 feet below the surface of the ground and the yield determined at this point.

2. The construction of wells in sand or gravel. In driving wells through sand or gravel, it is essential that the drive pipe be of strictly wrought iron and equipped with patent recessed couplings, and care must be taken so that the ends of the pipe butt in the couplings and that the pipe be shod on the lower or cutting edge with a steel drive shoe. The reason for the pipe butting in the couplings is to carry the effect of the blow of the tools directly through the pipe to the drive shoe instead of having the impact come upon the threads in the couplings.

The proper strainer and the placing of it is the next point to be considered. If the strainer is to be placed at the bottom of the well, this may be done either by driving the pipe through the water bearing strata, introducing the strainer, and jacking back the drive pipe so as to uncover it; or the drive pipe may only go to the top of the water bearing sand and the strainer pumped or driven into proper position. In the first case the strainer may be plugged before being lowered, but chances would be taken in the ability of the well driller to jack back the drive pipe. In the latter case, difficulty is sometimes found in placing the plug securely. In either method of construction, it is essential that means be taken to prevent sand from running up alongside the strainer between the top of the strainer and the well casing. This sand is kept out either by putting in a

lead packer or by continuing an extra line of pipe from the strainer up to the surface of the ground. Where the lead packer is used, the strainer is lowered into the hole, and in order to withdraw it any time, considerable difficulty is usually found in getting hold of it and getting it out of the well without destroying the strainer. As a general rule, it is better to lower the strainer into place by means of piping extending all the way to the surface of the ground and then, if it is necessary at any future time to withdraw the strainer, it is a comparatively simple matter to do so. In case the water is found in three or four strata with some distance between them, it is necessary to drive the pipe to the extreme depth and then lower the strainers into place with the proper connecting pipes between them, and then jack out the well casing at least as far as the top of the uppermost strainer.

The operation of jacking back pipe is one involving risk on account of the pipe parting under the strain. The only precautions that can be taken are to sand pump freely and frequently when the pipe is being driven, have the strainers on the ground and lose no time in placing the strainers before jacking back the pipe, so that the sand and gravel will have as little time as possible to pack around the drive pipe couplings. Cutting the drive pipe may be resorted to in case it is unnecessary to withdraw the lower part of the drive pipe, which may have been driven to give the necessary amount of submergence in the case of an air-lift well. The necessity of insisting upon the pipe being butted in the coupling is observed more particularly when jacking operations are required, because if the pipe is not butted there is even greater danger of stripping the threads. In case a pipe parts when being jacked back, it may result in a lost well.

3. Under the third heading, where water may be obtained from the formations above the rock and from crevices in the rock, the construction of the well differs in no way from those referred to in the first two actions.

METHODS OF PUMPING

The pumping of driven wells may be done either by suction, deep well pumps, rotary or screw pumps, or the air-lift. In case the water rises high enough in the wells to be pumped by suction, it is unnecessary to speak of this other than to say that method of pumping is familiar to anyone who has ever done any hydraulic work. The only

prime necessity for a successful suction plant is tight suction lines, and good foot valves.

In regard to deep well pumps, these may be used when only limited supplies are required and where the water does not rise in the well high enough to make an air-lift economical. The question of whether to use single acting well heads with single acting barrel, or single rods with double acting barrel or double rod heads with double plungers depends entirely upon conditions. Except under extreme conditions, the speaker does not believe it advisable to use deep well pumps where there are more than two wells on account of the spacing between the wells and the necessity of building separate pump houses over each well and for other obvious reasons of economical pumping.

For any number of wells scattered as they usually must be over quite an area, the air-lift system has proven itself to be the most available method for delivering a large supply of water on the surface of the ground. It is not advisable, however, to use the air-lift except under extraordinary conditions for delivering the water higher than to the level of the ground. At best the air-lift is an expensive way of pumping, but where the water is obtained in large volume below suction limits, it would seem to be the only possible method. The air-lift system has the great advantage of not having any moving parts in the well, and there is absolutely nothing to get out of order in the air-lift itself. The moving parts of the system are all in the air compressor in the engine room, under the eye of the engineer. The engine room may be located at the most convenient point, taking into consideration the supply of fuel, and the furthest well may be a mile or more away from the air compressor. If the air lines are correctly designed and properly buried, there need be but little loss of pressure. The main fault that the speaker has found with a great many air-lifts throughout the country has been in the air-lift piping in the wells. It is a familiar fact that a prime consideration for an economical air-lift is that there should be 60 per cent submergence. For instance, in a 100-foot well, there should be at least 60 feet of water when the well is delivering its yield; but the principal trouble is found in the design of the air and water piping, so that the compressed air is delivered at the bottom of the uptake water pipe with as little loss by friction as possible, and that the uptake water pipe is designed so as to deliver the water, without being so large as to have an extreme amount of slip or so small as to

develop excessive friction. Evidence of faulty design is shown by the discharge being in alternate pistons of water and air. In a properly designed air-lift system, the water should be discharged in a practically uniform stream, with very little surging. A great many foot-pieces have been designed which have for their object the spraying of the air at the bottom of the uptake water pipe so as to introduce the air into the water in streams of very fine bubbles. It was discovered early in the development of the air-lift that the finer the spray could be made, other things being equal, the more efficient the air-lift became; but no foot-piece that was ever designed can work efficiently if the air pipe leading down to it and the uptake water pipe from it are not of such sizes as are suitable for the particular problem involved in that well. The great object to be accomplished by any foot-piece is to offer as free and clear a water passage as is possible so that there will be no eddies formed in the water column which cut down the velocity and impair the efficiency. Above the foot-piece the mixture of air and water should have a pipe with as smooth surfaces as it is possible to obtain.

The three methods of piping wells may be termed: (1) the outside air pipe; (2) the inside air pipe; (3) the annular system. In the first case the air passes down outside the water pipe and into some type of foot-piece or openings at the bottom with the water passing up through the inside of the water pipe. In the interior pipe system the air passes down the inside air pipe to a foot-piece or nozzle, and the mixture of air and water is blown upward between the outside of the air pipe and the inside of the water pipe. In the annular pipe system, one pipe is within the other, the space between the two pipes being the downtake air column, and the interior of the inside pipe being the uptake water discharge pipe. It is impossible, without an exact knowledge of the conditions, to determine which of these three systems it is best to use, assuming that the proper areas are available in each case for the amount of air necessary and the amount of water required to be lifted. There are cases where the diameter of the well is so small and the amount of water to be delivered so large that there would not be room in the well for the outside air pipe, in addition to the uptake water pipe. In this case, it might be better to use the well casing as the downtake air pipe and only provide an uptake water pipe. This arrangement, however, is sometimes impossible on account of air leakage through the joints of the well casing, which were opened up when the well pipe

was driven. It is very hard to generalize and lay down rules for piping up wells on account of the different yields, depths and submergence of wells, and this is sometimes still further complicated by the number of wells that have to be pumped. With a great number of wells to be pumped from the same air compressor, very delicate adjustments are required so that all the wells may be started at the same time. The speaker believes that it is preferable to use a single air line, with outlets to each of the wells, rather than separate air lines from the pump house to each of the wells, both as a matter of economy of installation and economy in the use of air. The plea sometimes made that independent air lines to each well allow of adjustment within the engine room is valid because the place to adjust the well is at the well itself, and if the plant is properly designed originally, it should not be necessary to adjust the wells except at considerable intervals of time, and then only because of the increased requirements made on the plant, or fluctuations in the wells themselves.

Another rule, the observance of which should be insisted upon, is that the air-lift should only be used to deliver the water high enough above the ground to allow of a flow to a surface suction basin close by the force pumps.

The writer has not referred to air pressure machinery, but considerable economies can be made in this part of an air-lift system by installing compound and condensing machines and by 2-stage air ends. The great loss of economy in the ordinary air-lift system, however, is not in the engine room but in the air-lift pump in the wells. Insufficient submergence, caused by pumping too great a quantity from a well, and thereby lowering the head to a point where the increase in the amount of air necessary is out of all proportion to the quantity of water obtained, or by the use of piping either too large or too small. No foot-piece ever designed will do the impossible, but a properly designed foot-piece in connection with correctly designed air and water pipes will make the air-lift an important factor in the pumping of deep wells, and a properly designed air-lift system in connection with wells that have a good flow of water will result in pumping costs which will compare favorably with the cost of some surface water supplies that have to be filtered.

DISCUSSION

Mr. Chester R. McFarland: What do you find to be the most efficient velocity of the water rising in the pipes?

Mr. J. D. Kilpatrick: The most efficient velocity depends upon the air pressure, the size of the pipe and the depth of submergence. The velocity should be so low that the friction in the uptake pipe is negligible.

A Member: What is the highest efficient velocity which you can get?

Mr. J. D. Kilpatrick: As stated before, this depends upon the pressure. The speaker has never made any experiments to determine the velocity in feet per second of the discharge of the air-lift well, but in accordance with common practice, has made calculations in gallons of water discharged per square inch to the area of the uptake water pipe. In a deep well with high air pressure the speaker has discharged as high as 29.5 gallons per square inch, and recently, in New Jersey, was able to obtain a discharge of 31 gallons per square inch. With shallow wells, and consequently lower air pressure, the usual discharge is from 12 to 15 gallons per square inch.

Mr. Chester R. McFarland: The water had to travel the whole length of the pipe or you would not have had a discharge.

Mr. J. D. Kilpatrick: That is true. The velocity is a question of simply dividing the area of the pipe by the amount of water discharged per minute to get the velocity.

Mr. Chester R. McFarland: In an experience extending over a period of about twenty years, the speaker has been led to believe that each individual case must be treated according to the conditions as they are found, and that a deep well with a very great submergence and high lift will require a greater velocity than the one of much less depth, to secure the highest efficiency of the work done by the compressor. This being the case, for the same quantity of water delivered from a deep well the area of the water pipe should be much less than that in a shallow well.

MR. J. D. KILPATRICK: The government specifications issued by the quartermaster's department of the United States Army seem to be based upon the wrong conception of the operation of the air-lift. These specifications call for double, extra heavy pipe on the top, extra heavy pipe for the middle lengths, and standard pipe for the lowest lengths. Piping the well up in this manner means that the area is smaller at the top than it is at the bottom. The arrangement of the pipe should be reversed, that is, the smallest diameter should be at the bottom, and the largest diameter at the top. The reason for this is that the compressed air which is jetted into the water at the bottom is at its maximum pressure, and the bubbles are consequently smallest. As they travel upwards in the discharge pipe, they expand, and the pressure becomes less, with the result that more area is necessary at the top of the water discharge pipe than at the bottom, on account of the greater space occupied by the expanding bubbles of air, the quantity of water being the same at the bottom as at the top.

A MEMBER: What do you do when you have a rock only about 150 feet down?

MR. J. D. KILPATRICK: Let us suppose that we drive a 10-inch pipe above the rock, and desire an 8-inch hole in the rock. The operation would consist in driving a 10-inch pipe down to the rock, and the well driller will then continue with his 10-inch bit and make a 10-inch hole in the rock far enough to pass through the seamy top surface of the rock. An 8-inch pipe, with ordinary couplings and full lengths, is lowered with a coupling on the bottom of the lowest piece. This 8-inch pipe is lowered into the 10-inch hole, and the coupling on the bottom firmly set on the bottom of the 10-inch hole in the rock. The space between the outside of the 8-inch pipe and the inside of the 10-inch hole in the rock is filled with liquid cement grout up to the top of the rock. The well driller then proceeds to drill the 8-inch hole in the rock as far as necessary, and at some convenient time pulls out the 10-inch pipe which was driven from the surface of the ground down to the rock; the reason for withdrawing the 10-inch pipe is that there is no necessity for it, and it is available for use in another hole.

Several members have asked regarding the advantages of blasting or shooting a rock well. The answer would be that shooting a well

is resorted to in the oil regions to break up the oil-bearing sand, when this has been encountered. In shooting a well for water supply, a greater flow can sometimes be obtained if you are absolutely sure where the water bearing fissure in the rock has been encountered. The trouble with most well builders is that they cannot determine this exact point, and it may be that the shot is set at the wrong place, and may result in the closing up of the water bearing fissure instead of enlarging it. As a general rule the speaker does not believe that blasting a well is a sure way of increasing the water supply from that well, but at the same time there are a number of cases in which it has proven very successful.

Mr. John W. Moore (by letter): The writer has had a wide experience in designing and remodeling air-lift pumping systems and the question the gentleman has raised as to the proper speed of the air and water in the eduction pipe is of very great importance. When this most advantageous speed has been determined for all conditions the writer suggests that with the information now at hand the average consulting engineer will be able to design successful air-lift pumping systems of the highest efficiency.

It is apparent that a constant velocity is neither desirable nor possible; therefore it would follow that the best that could be done would be to ascertain the maximum and minimum permissible velocity at both the lower and upper end of the eduction pipe, the velocity at the intermediate points to be governed by the diameter of pipe available and possible to install in the well.

The writer after running tests on many air-lift pumping plants of his own and other designs has decided on what he believes to be the most advantageous velocity of the air and water in the eduction pipe for lifts of from 30 feet to 175 feet.

If observations of plants the writer now has under construction should verify the information secured during the last four years, the writer will be pleased to lay such information before those of this Association who may be interested.

Mr. M. N. Baker: The speaker well remembers the water-finders, Hartdegen and Schnee. He had come to New York a few years before, and it was his duty to accompany those gentleman on several expeditions. On one of these we had some large hose with water running through it stretched around on the floor of a large vacant building. We took Messrs. Hartdegen and Schnee up on the floor

above and had them chalk out their indication of the stream of water. It is hardly necessary to say that they did not come anywhere near it. Of the many who witnessed their demonstration one man was a member of the American Society of Civil Engineers and another has since been a prominent official of the American Institute of Mining Engineers.

A few years ago the government auditor of municipal accounts refused to audit a bill that a British town council had incurred for water finding, and the members of the town council had to meet the bill out of their own pockets.

Hartdegen and Schnee shrouded their water-finder in mystery. Waterfinders of a later and the present day claim to use "electrical" instruments and put forth clever but blind explanations as to how they operate.

In 1910 some enterprising water-finder succeeded in interesting the Agricultural Department of India to make an investigation of his device. The department published an interesting little pamphlet purporting to show that the water-finder investigated was a good thing. That pamphlet has recently been circulated in this country by some one giving his address as Providence or Pawtucket, Rhode Island.

Mr. Wirt J. Wills: The speaker simply wants to rise to thank Mr. Kilpatrick for having introduced a subject that is very near and dear to him. The speaker has been a member of the American Water Works Association for ten years, and with the exception of one engineer making a feeble attempt to say something about ground waters, this is about the first time that anything has been mentioned in regard to pumping from deep wells, or at least anything in an exhaustive way. Representing presumably the largest artesian water plant in the world, all that the author of the paper said was very interesting to the speaker, who does not desire to make a talk on this subject, except to say that we have three systems in Memphis, all very successful. One invented by the speaker, the name of which he will not mention because it is not on the market, consists of fifteen one million gallon pumps, stretching over a distance of ten miles. During the drought, last summer, the longest dry season ever known in that country, our mayor published a card in the paper advising everybody to use all the water they wanted, but we kept up with the demand right along.

With thanks to Mr. Kilpatrick for introducing this subject, the speaker hopes in future meetings we will have more discussion on this topic.

Mr. Oscar Bulkeley: The speaker would like to ask Mr. Kilpatrick if he has found a good method of drilling a well so as to be sure of securing a straight bore. Of course it makes no difference if one intends to pump with air, but it makes a very vital difference if any other type of pumping equipment should be used. Perhaps the rotary method of drilling is the most successful, but the speaker wonders if Mr. Kilpatrick can furnish any information on this subject.

Mr. J. D. Kilpatrick: In driving a pipe it must be remembered that the direction of the hole is entirely dependent upon the threading of the casing. The well driller sets his first length of pipe as near vertical as he can, drives this to its depth, screws on another length, drills that, and sand pumps and drives till he is ready for the other length, etc. The straightness of the hole depends upon the care with which the pipe company has threaded the pipe. The reason that so many well drillers get a crooked hole in the rock is that they drill with a slack cable. The well driller will usually get a straight hole if he drills on the spring of the cable, that is, with the tools hanging free in the hole, the distance off the bottom depending entirely upon the length of drill cable. In drilling with a taut cable the tools hit with a sharp blow, which is caused by the fact that the up stroke of the walking beam corresponds with the stretch of the cable. In drilling with a slack cable the tools do not hang free and clear in the hole, and the length of the stroke is cut down considerably. It is a very difficult job to drill a straight hole even with the best of care, if the rock is in layers of very hard and very soft material lying almost vertically. In this case the tools will be sure to work over into the soft material and make a crooked hole, in spite of all precautions. Sometimes a guide can be put on the stem, but in an experience once in Mexico every method known at that time failed, and we were forced to drill with a rotary drill.

Mr. A. A. Reimer: The method outlined by Mr. Kilpatrick for obtaining a pipe joint in passing from soil to rock is of course a perfectly sure method; but oftentimes in fairly soft rock you can save

that expense if you have a good iron shoe. A well dressed shoe, you can drive into rock with a little care in keeping the tools going pretty close to the shoe all the time. The edge of the tool will cut say three-quarters of an inch of rock under the drive of the machine, so that you can actually drive your pipe right into the rock, perhaps 3, 4 or 5 feet. In some cases that is all that you need for cutting—a good drive. That is all you need in that character of rock; but in hard rock the other method, of course, is necessary.

Mr. J. P. Berry: We have four deep wells in our city, each being approximately 1378 feet deep, and we have had no trouble in drilling them straight. Three of the wells are 15 inches down to a depth of 100 feet and from there to the bottom they are 8 inches in diameter. One well is 20 inches to a depth of 200 feet and from there to the bottom 12 inches. These wells are pumped with centrifugal pumps. An agreement with the contractor was, that he must put down a dummy pump, the size of the pump to be used in the wells, to a depth of 200 feet and this dummy pump must pass in and out freely before any payments were made. This was to show that the hole was perfectly straight and that the pump could be inserted and taken out when needed.

These wells are pumped at the rate of 1,000,000 gallons per day. Two of these pumps are electrically driven with direct connected motors. One pump is electrically driven with a belt drive and one pump is operated by steam. These pumps have worked very satisfactorily with us. Electricity is purchased from a private company at a cost of 0.02 per kw. It costs about 0.01½ per 1000 gallons to put the water in the reservoir.

Mr. Oscar Bulkeley: The question of straightness is something that is of great importance; more than many realize. The speaker believes that there are a great many well men who have heard about straight holes, but have not got them. If we were to make a test of them we would find that they are crooked. There is a great deal of misrepresentation in regard to drilling a well straight. Contractors will say that they will drill a straight well, but they do not always do it.

Mr. Edward S. Cole: Will Mr. Berry kindly tell us how his vertical shaft and pump are lubricated.

Mr. J. P. Berry: The shaft goes down inside of a 3-inch casing, and the lubrication goes down inside of that. There is no water around the shaft. The shaft goes from the motor connection straight through. One pump ran 18 months without missing a day. Some Sundays it was shut down for an hour or two, but it ran the whole 18 months practically night and day, delivering 700 gallons a minute. Then it was taken out. It has been very economical.

Mr. Wirt J. Wills: To find out whether a well is straight, if you have a contractor who cannot tell you, make him take a looking-glass and by looking down with that you can tell if it is not overflowing.

Mr. Francis D. West: This has been an important and interesting subject and the speaker is glad to see that the fact has been emphasized that the air-lift is a very good means of pumping deep wells.

IMPOUNDED WATERS OF ALABAMA IN RELATION TO PUBLIC HEALTH

By Edgar B. Kay

The streams of Alabama for nearly a century have been utilized for navigation, public water supply and as sources of power in the operation of cotton mills, saw mills, grist mills, gins, and other manufacturing plants. In these operations numerous dams have been constructed, the flow of the streams for a time impounded, partially controlled and regulated for the manufacturers and users.

Within the last few years the plan of canalizing the larger streams in order to give the inland cities, iron and coal interests as well as the diversified agricultural and manufacturing industries, the advantages of water transportation, has resulted in the construction of many large dams and impounding basins extending for hundreds of miles along the Alabama water courses.

The development of long distance electrical transmission of power has made available the hitherto inaccessible and remote potentiality of streams, which are being harnessed for the service of man and use in the upbuilding of the Commonwealth. The impounded waters resulting from the construction of dams and structures employed in the operation of these hydroelectric plants are important links in the canalization projects of the government to aid navigation. In addition these dams serve the important work of flood prevention by assisting in the regulation of the discharge of streams.

Out of the recent improvement and utilization projects in Alabama, there has developed a great deal of litigation. This litigation has been inspired, almost entirely, by unscrupulous lawyers and land sharks, who have systematically canvassed the territory contiguous to these hydraulic works and have made the credulous country people believe that they could secure large sums from the corporations developing these hydroelectric plants. Many of these people who are the perennial victims of chronic malaria and hookworm anemia, have been led to believe that their latest troubles are entirely due to the formation of a large body of slowly moving

water in the vicinity, which body of water is nothing other than an enlarged section of the original river due to decreased velocity.

The largest power company in the state is at present defendant in some 700 suits, aggregating approximately $3,000,000 damages claimed, these suits being filed in the four counties through which the lake extends, caused by the dam at Lock No. 12 on the Coosa River.

It is the purpose of this paper to briefly outline the character of the impounded waters in Alabama, in their relation to public health and to call attention to the necessity of having carefully made preliminary topographic, geologic and sanitary surveys in connection with similar future projects.

DRAINAGE BASINS

The five principal drainage basins of the state are:

First, The Apalachicola Basin, draining to the Chattahoochee and Apalachicola Rivers, and entering the gulf at Apalachicola, Florida.

Second, The Choctawhatchee Basin, draining to the gulf through Choctawhatchee Bay.

Third, The Pensacola Basin, draining to Pensacola Bay and Perdido Bay, near Pensacola, Florida.

Fourth, The Mobile Basin, including the waters of Tallapoosa, Coosa, Cahaba, Alabama, Warrior and Tombigbee Rivers and draining into the gulf at Mobile, Alabama.

Fifth, The Tennessee Basin, draining into the Tennessee River and thence through the Mississippi to the gulf at New Orleans.

The water powers of the state are mainly in the Mobile and Tennessee basins, which practically cover the entire state, except a small area in the southeast corner.

From Westpoint, Georgia, southwards, the state line of Alabama is on the west bank of the Chattahoochee River where ordinary vegetation ceases to grow. This leaves all of the water power of the main stream on Georgia territory.

The Alabama Geological Survey, in coöperation with the United States Geological Survey, has for a number of years been engaged in a systematic investigation of the water resources of the state.

The annual average precipitation in the northern district of the state is 51.23 inches, and in the southern district 51.47 inches. There have been wide variations from the annual average precipi-

tation. In 1900 the average for the year was 66.73 inches and in 1904, the year of minimum rainfall and run-off, 39.58 inches.

While the proportion of the rainfall which appears in the run-off of the streams varies between very wide limits, depending upon the geological formations, the locality, etc., in Alabama, on an average, about 50 per cent of the rainfall is lost through evaporation, and the remainder forms the run-off of the streams; and curiously enough, only a small percentage of this run-off is supplied by the surface water alone, for most of it reaches the water courses by underground seepage.

In the course of this underground circulation the water reaches the surface from springs, many of which are very large, such as those at Tuscumbia, Huntsville, and Jacksonville, which are the sources of the municipal water supply, from ordinary shallow and deep wells, and from artesian wells.

The main channels in this run-off system are navigable all the year for boats of light draft, except the Tallapoosa and Coosa Rivers, and the canalization of the Tombigbee and Warrior Rivers, by the construction of seventeen dams and locks, has established water transportation from the Birmingham district to the gulf. A fleet of self-propelled barges of 1000 tons capacity each is now making regular trips between Tuscaloosa, Alabama, and New Orleans. Iron is also moving from Holt, north of Tuscaloosa, to the gulf by the water route.

It may be said in a general way that the streams have their greatest fall in passing from an older to a younger geological formation. Tallassee Falls, on the Tallapoosa, and Wetumpka Falls, on the Coosa, are made in passing from the Crystalline to the Cretaceous. Those on Talladega Creek and other small streams in entering the Coosa Valley from the southeast in Talladega, Calhoun, and Chelburne Counties, are from the Crystalline to the Paleozoic. The shoals above Centerville, on the Cahaba, above Tuscaloosa, on the Black Warrior, and near Tuscumbia, on the Tennessee River, are made in passing from the Paleozoic to the Cretaceous. As the Coosa River runs off of the Paleozoic onto the Crystalline near Talladega Springs, the shoals above this point reverse the general order by being made in passing from a younger to an older formation.

The Crystalline area in Alabama is a plateau ranging from 500 to 2000 feet above sea level, of triangular shape on the east side of the state. The rivers flow over bed-rock in a succession of shoals and

eddies between high hills, and present conditions most favorable to the development of water powers with high head. On the Tallapoosa River at Tallassee Falls, a head of 64 feet has been partially utilized for a number of years in the operation of cotton mills, and also a 40-foot dam about three miles above Tallassee is utilized for the generation of electric current which is transmitted to Montgomery. At Cherokee Bluffs, about 15 miles above Tallassee, a dam 125 feet to 150 feet in height is contemplated by the Alabama Power Company.

The falls on Coosa River, from Marble Valley to Wetumpka, are 235 feet in 45 miles. During the past year a dam 60 feet in height has been completed at Lock 12 on this river, the hydroelectric power developed at this site being transmitted to the Birmingham district.

The Paleozoic area includes the greater portion of northern Alabama, being bounded on the southeast by the Crystalline area, and on the southwest by the Cretaceous and later formations of the Coastal Plain. The Paleozoic area is somewhat higher than the Coastal Plain, and slightly lower than the Crystalline area. Its rivers have considerable fall. There are many important creeks and many large limestone springs in this region. The area is rich in coal and iron, the most productive mines being in the drainage basins of the Cahaba and Black Warrior Rivers, the Cahaba River has a fall of 121 feet in 21 miles. The Black Warrior River above Tuscaloosa has a fall of 100 feet in 30 miles. The Tennessee River above Waterloo has a fall of 155 feet in 41 miles, 85 feet of which is in a distance of only 14 miles.

The Coastal Plain is a large area in southern and western Alabama, covering about two-thirds of the state, and is underlain by Cretaceous and younger formations. In the upper portion of this area the streams are not sluggish. There are many streams that have a constant water supply and sufficient fall for the development of good water powers. One of these is the Pea River, the main tributary of the Choctawhatchee River, on which a dam giving an effective head of 31.4 feet has been constructed and the power developed is being transmitted electrically to Troy, Alabama, 32 miles distant.

Birmingham's principal source of water supply is derived from the Cahaba River, on a branch of which—the Little Cahaba—a large impounding reservoir has been built.

The dams on the Warrior are utilized at present only for naviga-

tion, although efforts are being made to utilize the power at Lock 17 in connection with large impounding reservoirs to be built on the Mulberry Fork of that river.

Only a beginning has been made in the development of the great water power resources of the Alabama rivers. The largest available powers remain undeveloped. Of the nine plants now in commission, the Dadeville, Sylacauga, and Goodwater plants are municipally owned; the other hydroelectric plants are the state convict department's plant at Speigner, the Etowah Light and Power Company, near Gadsden; the plant at Lock No. 12 on the Coosa River owned by the Alabama Power Company; the Montgomery Light and Power Company, above Tallassee Falls; the Pea River Power Company, at Elba; and the Centerville Light Company, near Centerville.

While only a beginning has been made in the development of hydroelectric powers in this state, numerous power sites have been utilized ever since the state was settled, for manufacturing purposes, such as the operation of cotton mills, cotton gins, grist mills, saw mills, etc. In the Geological Survey of Alabama Reports will be found a list of 987 utilized powers on Alabama streams.

It is therefore seen that this state is abundantly supplied with large water courses, with many beautiful tributaries having branches reaching every part of the commonwealth; and that numerous impounding basins have been constructed during the past century, mostly for manufacturing purposes, while more recently large dams have been built either to aid navigation or in connection with hydroelectric developments.

IMPOUNDED WATER IN RELATION TO PUBLIC HEALTH

The waters referred to in this paper are those caused to be temporarily stored by dams on Alabama streams, in which running water will always be found and by reason of which fact there is practically always a forward or downstream movement of the water impounded.

In the case of the pool above Lock No. 12 dam on the Coosa River—the back waters of which extend upstream about 30 miles—there is a complete renewal of the impounded water every five days during normal stages of the river.

Whether the effect of a dam constructed in any locality is to lessen or increase the healthfulness of the community contiguous to the

lake or pond created by the dam, is a question which can only be determined by careful topographical and biological surveys of the site and neighborhood before and after its construction. It is first necessary to ascertain the change in physical conditions before any conclusion can be arrived at. The primary purpose of the survey is to determine:

1. The influence impounded waters exert on the health of the surrounding community.

2. The conditions which affect this influence favorably or otherwise for good or for ill.

3. The measures to be taken to minimize deleterious effects and to increase to a maximum the beneficial effects.

The importance of the problem can be readily understood since it concerns the impounded waters of many of the large power and manufacturing plants now utilizing water power.

While nearly all of the litigation at present in the Alabama courts relating to the influence of impounded waters is in connection with the incidence of malaria, there have been many cases involving the pollution of water in ponds and of streams by emptying into them sewage, manufacturing wastes and mine waters.

In the *Southern Reporter*, volume 60, will be found the Alabama Supreme Court decision, January 16, 1913, in the case of W. H. Hosmer vs. Republic Iron and Steel Company.

Several years ago the Republic Iron and Steel Company built a small dam across one of the tributaries of the Warrior River, at a place called Greeley, in the northern part of Tuscaloosa County, to impound water for use at its ore mine. During the dry season there is very little running water in the branch on which this dam was built.

The facts made by the complainant are that, for a long time previous to the grievance complained of, he occupied and resided with his family, including intestate, who was his son, upon a piece of land near Greeley and that after plaintiff's residence and occupation upon said land had commenced, the agents and employees of defendant acting for it . . . . dammed up certain water and thereby created a lake of water . . . . near his residence, being so close thereto as to affect his health and the health of his said family, and the enjoyment of his residence. It is then alleged that defendant was engaged in the development of iron and other minerals, and had caused said lake or pond to remain there for a long time and had placed or caused to be placed in said pond various substances, which are named, and thereby caused or allowed said water or lake to give off and out foul and unwholesome

and noxious air and caused said premises on which plaintiff resided to become unhealthy, causing plaintiff's boy to become sick so that he died; and plaintiff alleges that said sickness was proximately caused by the wrongful act or omission or negligence of defendant as aforesaid in building, maintaining or constructing said pond. . . . . The demurrers were that the cause of action did not survive to the personal representative and that the damages claimed did not survive. That there was nothing to show that plaintiff intestate was the owner of the land or had any possessory or leasehold interests therein; that the damages claimed were purely consequential and that no right of action was shown.

The Court held: The effect of the complaint is to aver that the death of the plaintiff's intestate, on account of which he sues, was caused by an issue of foul, unwholesome and noxious air from a pond which defendant corporation constructed in the neighborhood of his residence, where intestate, his minor child, lived with him. . . . . We are not required to know how plaintiff will prove the causation alleged; but accepting the allegation as true and provable on demurrer, there will be no question but that it shows damage peculiar to intestate, not merely in degree but in kind. . . . . It is obvious that to maintain an action for injury affecting the value of the freehold the plaintiff must have a legal estate. But if noxious vapors and the like cause sickness and death to one who has a lawful habitation in the neighborhood, no sufficient reason is to be found in the accepted definition of nuisance nor in the policy of the courts which would discourage vexatious litigation, nor in the inherent justice of the situation, as we see it, why the person injured, or his personal representative in case of death, should not have reparation in damages for any special injury he may have suffered, although he has no legal estate in the soil. Certainly a child has the right to live under his father's roof—is a lawful occupant of his father's home and in our opinion he should be accorded the same measure of protection against the construction of nuisances in the neighborhood which are so noxious and long continued as to materially affect his physical well being. . . . .

In the building of dams and the impounding of water for manufacturing purposes in this state, except in saw mill projects, it has not been considered worth while to even remove saw timber within the submergence areas. Experience has shown that in a year or two after submergence or partial submergence the timber dies; the limbs and tops first fall and with the seasonal floods are carried away. Within a few years the trunks fall and disappear in the same manner. Thus by these natural processes the areas of these impounded waters are cleared, and the banks below the normal water level are made free from vegetation. These conditions may be observed in all parts of the state.

About six miles west of Troy, on the south side of the Atlantic Coast Line Railway, there was built about five years ago a fish pond, by impounding the waters of Mill Creek. At the dam the pond is

approximately a quarter of a mile in width, and the pool extends upstream for a distance of about one mile. The timber, of which there was a considerable amount of second-growth pine, was allowed to stand. All the partially submerged timber except a little bay and magnolia died during the first summer after submergence, and most of the timber has fallen. The pond is not an attractive place from an aesthetic viewpoint, but for fish it is excellent. There are some places around the fringes of this pond where the water backs over flat surfaces producing conditions favorable for the breeding of mosquitoes, but the relative area of these overflowed places is very small compared with the large areas of swampland permanently submerged by the pond. This pond has resulted in the creation of a combined pleasure and health resort out of what was formerly a malarial swamp. In the building of this pond, as in all other projects for utilizing the waters of the state, the question of effect upon public health was not raised until the suits against the Republic Iron and Steel Company were filed, of which mention has already been made.

In 1910 the state of Alabama began the construction of a dam across the valley of Mortar Creek, at Speigner, Alabama, at which place is located the state cotton mill operated with convict labor. The state owns about 3500 acres at Speigner, and the Mortar Creek bottoms include about a thousand acres of the state property. These lands were covered with a dense growth of timber, little of which was suitable for manufacturing purposes, and the lands even if cleared would not have been suitable for cultivation, being for the most part swamp and overflow lands. This tract being located practically in the center of the state's property was a menace to the health of the community. It was a veritable mosquito heaven.

A dam nearly a mile in length across the valley has been completed and a lake of 800 acres in area created. All the standing timber within the submerged area has been removed. The power created by this development is now being utilized to operate the electric light system, water works plant, grist mill and for part of the year to operate the cotton mill. The work was all done with convict labor. The permanent submergence of those 800 acres of swamp land has added greatly to improved public health conditions in that vicinity.

In order to be able to carry the water level of the Speigner dam to the desired height, it was necessary for the state to acquire about 75 acres of privately owned lands. Being unable to negotiate for

these lands, condemnation proceedings followed. The state contested the price fixed by the commission for the condemned land, on the assumption that the land appropriated was waste and uncultivatable property, and that the remaining portion of contiguous lands would be increased in value by reason of the state's constructions, being made more healthful and habitable. In this view, the state health officer concurred, and was a witness for the state.

In the canalization of the Tombigbee and Warrior Rivers the United States government has built in all 17 locks and dams. Lock No. 1 is located on the Tombigbee 111 miles above Mobile, and Lock No. 17 is located on the Black Warrior 388 miles above Mobile. The backwater above Lock 17 extends up the Locust Fork of the Warrior to a point 425 miles above Mobile, and on the Mulberry Fork to a point 444 miles above Mobile, the confluence of these forks being 408 miles above Mobile. In addition to the pool extending 53 miles up these two main forks of the river, the backwater above Lock No. 17 extends up small tributary streams for a total distance of about 20 miles. The total distance, or length of the pool above Lock No. 17 created by the 63-foot dam, is 93 miles. Outside of the natural banks of the river and its tributaries, about 3500 acres of land has been submerged. In the construction of this lock and dam no effort has been made by the government to cut the timber that has been submerged.

In all the improvement work on the Tombigbee and Warrior Rivers, the only timber removed was that which might obstruct navigation. This is the same policy that has been followed in the construction of the Panama Canal.

So far as records are available, and from the testimony of many physicians whom the writer has interviewed, the year 1900 was the most unhealthful along the Warrior River from Tuscaloosa to Demopolis. In the late summer of that year malaria was epidemic not only along the Warrior and Tombigbee bottoms, but extended far back into the neighboring country and higher lands. Malaria prevailed in fact in all parts of the state.

At that time there were no completed locks. The dams were in course of construction, but the waters in both rivers had an unobstructed flow. During the summer there were two exceptionally high stages of the rivers, causing streams everywhere in the state to overflow their banks, and to spread over vast tracts of land in the Coastal Plain. The heavy rainfall of that season undoubtedly cre-

ated numerous favorable breeding places for mosquitoes, which ordinarily do not exist.

Assuming that the unprecedented rainfall of the summer of 1900 explains the unusual amount of sickness in the autumn of that year, yet the fact remains that since these two rivers have been completely canalized, there has been less and less malaria each succeeding year, and the health conditions along both rivers have steadily improved.

The impounded waters in the Birmingham district include a reservoir on the Five Mile Creek and a reservoir on the Little Cahaba River which are used as sources of supply by the Birmingham Water Company and are estimated to have during drought a combined capacity of 42,500,000 gallons per day. An excellent system of treatment and filtration is employed before these waters are served to the public.

In addition to the above reservoirs, the Tennessee Coal, Iron and Railroad Company built for manufacturing uses an impounding reservoir on Village Creek near Ensley, capable of furnishing daily 50,000,000 gallons in dry seasons. Artificial lakes have also been built at East Lake and West Lake near Birmingham. The sites of all these impounding basins were cleared of standing timber to the water line before submergence.

Tuscaloosa is the only city outside of Birmingham in Alabama drawing its public water supply from a large impounding basin, the supply being obtained from the pool caused by Lock No. 12 Warrior River.

When the Spring Hill pumping station of the Mobile water works was built in 1900, a dam across Three Mile Creek was constructed, which created a shallow pond submerging several acres of dense vegetation. Superintendent M. F. Sullivan in his report, dated Mobile, March 15, 1915, says:

> In my report to the mayor and general council on May 15 I recommended that the dam across Three Mile Creek at the pumping station be opened up and a new spillway be constructed, the crest of which would be on the same elevation as the normal water surface of the creek, thereby eliminating the pond feature of our water supply, as same had not been cleared of all vegetation, top soil, etc., and the capacity of the creek being sufficient to supply the future demands for several years, no storage of water was necessary. But before anything was done in the matter the unprecedented rainfall of June 26 (12.67 inches in 24 consecutive hours) caused an enormous rise in the creek, and the 50-foot spillway provided for the escape of only a small portion of the storm water, and as a result the water soon washed out about 150 feet of the dam and also the old spillway.

The above enumeration covers the list of impounded waters in Alabama. It will be seen that only two cities derive their public water supply from impounding basins and these supplies are mechanically treated before being used.

The relationship of impounded waters in Alabama to public health is therefore limited to the influences they may have other than through water borne diseases such as typhoid, para-typhoid or para-colon fevers, cholera, etc., and may be studied in their relationship with reference to

1. Humidity and changes in hygrometric conditions.
2. As a source of foul or deleterious odors.
3. As breeding places of mosquitoes.

The complex relations of humidity and evaporation make it practically impossible to compute, with any degree of accuracy, evaporation over an extended surface of a water shed or drainage area—or to ascertain the effect on humidity in the various river basins, due to the comparatively minor changes in the surface conditions caused by clearing of timber lands or adding to the exposed water surfaces by the construction of impounding basins. The average annual relative humidity from Mobile to the gulf is over 80 per cent and for the rest of the state from 70 to 80 per cent. A given air space at a given temperature can contain only a definite amount of water. If it contains less it will endeavor to fill up by evaporation; if it contains more the surplus moisture will condense. The higher the temperature the more moisture it takes to saturate the air.

The experiments of Desmond Fitzgerald on evaporation from water surfaces (see *Trans. Am. Soc. C. E.*, vol. xv, p. 581) show that evaporation depends upon three elements: The vapor pressure corresponding to the temperature of the surface of the water; the vapor pressure corresponding to the dew point of the atmosphere, and the velocity of the wind.

For the five months, June to October inclusive, the probable average daily evaporation from exposed water surfaces in Alabama is about 0.16 inch and the average rainfall throughout the state approximately equals in depth the amount of evaporation from the water surfaces for the year.

Since the absolute humidity decreases rapidly from equator to the poles but decreases more rapidly in the interior of the continents than over the oceans, it is evident that even the relative humidity in any section of the state which is highest at night and lowest in

the hottest part of the day, can be but slightly influenced by changes in the areas of natural water surfaces since these areas are insignificant compared with the ocean surfaces from which the atmosphere draws its chief supply of moisture. Furthermore the areas of the water surfaces of the impounded streams in many of the canalization projects have been but very slightly increased because of the steep natural slopes of the banks. The total areas of these impounded water surfaces compared with the land areas are exceedingly small. It is therefore evident that the impounded waters have little or no effect upon the normal humidity or atmospheric conditions in their vicinity.

2. (a) As a source of foul or deleterious odors, impounding reservoirs will be considered into which vegetable, animal or mineral matter is transported as in the Village Creek reservoir of the Tennessee Coal, Iron and Railroad Company already referred to and a more complete description of which will be found in the article on "Water and Air Movements," by Mr. W. F. Wilcox (PROCEEDINGS OF AMERICAN WATER WORKS ASSOCIATION, 1913, p. 310). When this reservoir was originally planned, fears were entertained that at some

future time it might become so filled with putrescible matter as to be objectionable, causing sickness to the adjacent population. It was therefore determined to take all possible precautions during construction, and to keep daily observations of all physical conditions and to make periodical examinations.

A pipe line 8 miles long was constructed to remove waste from a by-product plant; a sewage disposal plant was put into service to treat sewage reaching the reservoir and at coal mines and washers settling arrangements were constructed; from the reservoir basin vegetable matter was removed before the water was impounded. These precautionary measures were undertaken because this impounding reservoir is strictly a conservation proposition and during periods of drouth there will be a considerable draw-down on the basin and no overflow. The waste from the by-product plants and mines carried around this reservoir, empty into Village Creek below the dam and are emptied through this creek into Locust Fork in the pool created by the dam at Lock No. 17 Warrior River. This last mentioned impounding reservoir is the largest in the state and receives into its waters the manufacturing wastes of the Birmingham

district, the mine wastes of the Warrior coal fields, the vegetable and animal wastes of a drainage area of approximately 4000 square miles and the human wastes of a population of about 200,000. Notwithstanding all these polluting influences the pool caused by Lock and Dam No. 16 immediately below this pool has never emitted foul odors except during the first fall season after its completion; the odors at that time being due to the decomposed land flora which had been submerged in the reservoir itself.

It is likely that the same odors from decomposing vegetation will be noticed this fall around the margins of the reservoir caused by Lock and Dam No. 17.

So far as records are available, the impounding reservoirs in this state, into which animal, vegetable or mineral matter is transported, have not been the source of foul or deleterious odors, except when the waters were first impounded.

(b) Whipple says (*"Microscopy of Drinking Water,"* p. 186): "Almost all surface waters have some odor. Many times it is too faint to be noticed by the ordinary consumer, though it can be detected by one whose sense of smell is carefully trained." This statement is undoubtedly true with reference to the impounded waters of Alabama during the late autumn, when decaying vegetation of the catchment and on the littoral is carried into the reservoirs. These odors may be unpleasant occasionally, but in the basins herein considered by reason of the dilution due to the large bodies of water, the almost constant forward or downstream movement of the waters, and the frequent rains causing freshets, the odors can not be said to be especially disagreeable or offensive. It is not conceivable that these odors could in any way be detrimental to public health.

3. As breeding places for mosquitoes.

MALARIAL FEVERS

Prevalence and Geographic Distribution in Alabama

The first available statistics which were studied were of the admissions of cases into the United States Marine Hospital at Mobile during the 10 years 1902 to 1911, inclusive. (See Public Health Reports, vol. XXVII, No. 52, Dec. 27, 1912, by Surgeon R. H. von Ezdorf.) Available statistics at the office of the Alabama State Board of Health begin with the year 1910, but are quite imperfect for the years 1910–1913 inclusive. This incompleteness of records is due to the failure of the physicians of the state to make the reports. In his 1912 report Surgeon von Ezdorf arrives at the following conclusions:

1. All forms of malarial fevers prevail in the state of Alabama.
2. Morbidity reports indicate that in September, 1912, about 1 person for every 50 population suffered an attack of malarial fever, and during October 1 person in 67 had an attack.
3. The types of infection, in order of preference, are: Tertian, esto-autumnal and Quartan.
4. The chronic type of malarial infection is proportionally greater in the colored race than in the white.

In every county in the state the reports state that there are swamps or poorly drained lands. Mosquitoes were reported as present in all counties for which information was given on the subject.

The same authority (see *Public Health Reports,* vol. 29, No. 18, May 1, 1914,) states that

The regions in the state in which malaria prevails to the greatest extent are apparently in the Tennessee Valley belt, which extends across the northern part of the state, and also in the central prairie region known as the "Black Belt."

The morbidity reports indicate that the disease exists in every county in the state, the tertian type being most prevalent.

The reported deaths from malarial fevers total 434 for the year 1913, which is equal to 2 per cent of the reported deaths from all causes, and is at the rate of 20.3 per 100,000 population.

The United States Public Health Service is now engaged in an investigation of the prevalence and geographic distribution of malarial fevers in the states of Alabama, Arkansas, Mississippi, South Carolina, Georgia, Florida, North Carolina and Tennessee. For the year 1913 cases were reported from every county in the states of Arkansas, Alabama, Mississippi; all counties in South Carolina and Florida, except one in each state, from which no reports were received, and in 138 counties of the 148 in Georgia. August and September are the months of greatest prevalence in all these states.

MALARIAL SURVEYS

The United States Public Health Service made malarial surveys in selected localities during 1913 in the states of Arkansas, Alabama and North Carolina, in which the topographic and climatic conditions of the locality, and social, hygienic and economic conditions of the communities and industries were studied. (See Reprints Nos. 156, 160, 172 and 193 from Public Health Reports.)

Dr. H. R. Carter, Senior Surgeon, United States Public Health Service, in charge of the surveys in North Carolina, read a paper on

"The Effect of Impounded Water on the Incidence of Malaria" before the meeting of the Southern Medical Society at Richmond, Virginia, November 9, 1914, in the introduction of which he says:

> Last fall a new problem was presented to me—the effect of large bodies of impounded water on the production of malaria. It was interesting; it was important and it was new. . . . . Of its importance there can be no question, as it is especially concerned with the large ponds of the power plants of the South; to which plants this country is looking for no little part of its future development. I was looking over a map of the Southern Electric Co. and a reasonable estimate of the cost of the plants there given as in operation would exceed $150,000,000 and as many projected. . . . . If these plants, or rather the ponds of these plants, are a serious menace to the health of the community, either they must not be allowed, or can only be allowed by rendering unhealthful, or even uninhabitable, a considerable area adjacent to them. In either case the loss involved is a very serious one, and the problem is certainly new.

Dr. Carter's paper read at Richmond and his report to the government published in *Public Health Reports*, vol. 29, No. 52, December 25, 1914, on "Impounded Waters," were the pioneer papers on the subject, contributing largely to our present knowledge of the effect of large bodies of water confined by artificial structures on public health, and indicating the character of surveys and investigations which should be made to obtain a broader knowledge of the subject.

A study of the impounded waters on the Coosa River in Shelby, Chilton, Talladega and Coosa Counties, Alabama, was made by Mr. J. A. Le Prince, sanitary engineer, United States Public Health Service, during the months of October and November, 1914 (see Reprint No. 257 from *Public Health Reports*), also of the same reservoir by Mr. J. V. Donley, Sanitary Engineer of the Board of Health of Alabama at the same time the investigations were being made by Mr. Le Prince. (See "Impounded Waters," by J. V. Donley, *Board of Health of Alabama Report.*)

During the period of the above investigations (October and November, 1914,) the writer spent about two weeks with local physicians in the same counties, making a special investigation of the sanitary conditions not only in the neighborhood of those homes near the reservoir but in many cases distant several miles from the pool.

The investigations which were inaugurated in the fall of 1914 will be continued during the present year by the United States Public

Health Service and doubtless by the State Board of Health of Alabama, with the object of determining (1) the influence of such waters on the incidence of malaria; (2) what conditions affect this influence for good or for ill; and (3) what measures can be taken to minimize the ill effect of such waters and to increase to a maximum their good effect.

The investigations during the fall of 1914 and those which are now proposed by the United States Public Health Service on the Coosa River basin, were doubtless inspired by the numerous suits (700) filed in the four county and circuit courts in which the reservoir is situated, for alleged damages due to the creation of this lake above Lock and Dam No. 12.

Since the dam was built in strict conformity to plans approved by the war department, the pool created by it becomes part of the national government's project for the improvement of navigation on that river, the power company incidentally utilizing the power created by the dam, has no authority in any way to change the level of the lake determined by the crest of the dam now built, except in so far as it may be permitted to draw down the lake level to a point that will not interfere with navigation or the operation of the locks when installed.

Mosquitoes

It has been proven beyond a doubt that:

1. Mosquitoes carry malaria from man to man.
2. That the disease can be contracted in no other way than by being bitten by malaria-carrying mosquitoes.

Just how many kinds of mosquitoes there are in the world today nobody knows. Distributed as they are, there are large areas in which the mosquito fauna is not known, and will not be for years to come. One of the greatest authorities (F. V. Theobald) states that the number of species will not be less than 1000. At present the known species are grouped in about 50 genera. Male mosquitoes, with probably rare exceptions, do not bite—only the females do.

The most common mosquito in Alabama is the Culex impiger, or common house mosquito, which has been reported from Alaska and is found in all the Southern States.

The Stegomyia calopus, or yellow fever carrier, is universally distributed over Florida and probably Alabama, having been identified

in 14 counties in 1913 from specimens received at the Marine Hospital at Mobile.

Everybody knows that the mosquitoes of the genus Anopheles are responsible for the transmission of malaria. The Anopheles punctipennis, the most common species in Alabama, is not however a carrier, or has not to the present time been shown to be a carrier. The A. quadrimaculatus and A. crucians are probably the chief carriers in Alabama.

Breeding Places of Anopheles

All mosquitoes breed in water and in Alabama probably at all times during the year, the intensity of development corresponding to temperature conditions, the greatest activity following the high temperatures of the late summer and fall. A study of the topography of Alabama shows there are breeding places in all parts of the state which may be designated as those of a "constant" and those of a "temporary" character. Those of a constant character are places found along poorly drained creeks, cane and cypress brakes, marshy places in woods and along river banks, ditches containing water at all seasons with grassy banks. The marshy places about springs and along small branches and creeks with wooded and grassy banks probably furnish the most favorable conditions for breeding even during the winter months. In such places larvae of the Culex and Anopheles were found in November and in February of the present year. On April 11 larvae of Culex were procured in great numbers in a spring fed grassy pool in a ravine near Lock No. 10 Warrior River, some of which hatched on April 18. Larvae from another pool near by obtained by the writer on April 14, hatched on the 19th of April.

It is evident that in these protected pools eggs or larvae have been present during the winter as well as mosquitoes in the immediate vicinity. The protection of the wooded grounds, evergreens and warmth of the spring waters, make such places ideal winter resorts and permanent abodes for the mosquito. The pools above mentioned are certainly complete breeding places, i.e., places developing imagos from eggs deposited at that place.

Temporary breeding places are found in poorly drained ditches, gutters, barrels, tin cans, bottles, hoof-prints of stock, pools in roads, or in water courses that dry out in a short time unless refilled. Such places may become for the time being a complete breeding place.

A place may be designated as incomplete when, although eggs are deposited there, yet imagos are not there developed from them, as in a creek or river completely scoured out by a freshet, all larvae being removed and either drowned or carried elsewhere. Such a creek may supplement an incomplete breeding place as a bayou or the backwater at creek's mouth transporting larvae that find shelter in the floatage sometimes found in such places.

In the investigations by the writer in Shelby, Chilton, Coosa and Talladega Counties, Alabama, in October and November, 1914, Anopheles larvae were obtained at or in the vicinity of practically all of the homes inspected and it was only necessary to locate standing, quiescent water to find them. Specimens were obtained from many wells from which water was drawn by buckets attached to ropes, from springs in the hollow and on the hillside, in the marshes and quiet waters along the banks of rivulets and small streams, pools in roadways. In fact wherever quiet water could be found, except in occasional places that had been heavily oiled, specimens were obtained.

The shores of the Coosa River were carefully examined in many places. Only at springy places along the shores and above the lake level and at the mouths of creeks in the dead water or at the head of backwater in bayous were we able to procure larvae, few of which were Anopheles. At no place were we able to procure or to see larvae in large numbers.

The writer was strongly impressed from observations made at that time and since, that the large streams with their impounding basins are not the important breeding places of mosquitoes in this state. It is true that eggs and larvae are transported into these streams and a percentage, probably small, mature and survive. Some favorable places for breeding will be found such as have hereinbefore been indicated; but these areas are relatively small compared with the natural and complete breeding places that have been permanently submerged. The writer believes when the facts are better known and the problem is more fully worked out, malaria control will become largely one of local sanitation and drainage. Malaria will then be largely prevented or eradicated by measures applied at or near the home.

Natural Enemies

The deep waters, wave action and currents of the impounding reservoirs described make such waters unfavorable places for the

breeding of mosquitoes. In the larval and wiggler stage, they have many enemies; minnows eat them, the larvae of dragon flies, beetles or mellow-bugs eat them, "disease attacks them, fungi get on them and kill them;" they die for lack of food, they devour each other, they get entangled or under leaves and drown, the water dries up and in this way millions perish before they are grown. Many perish while emerging from the pupa by reason of the capsizing of the cast-off skin serving as a boat.

Those that do hatch successfully meet new enemies among dragon-flies, bats, lizards, toads, frogs, night hawks and a host of other enemies.

SURVEYS NECESSARY

United States Government Surveys

The purpose of the United States Public Health Service Surveys now in progress has been already described.

In connection with the construction of Dam and Lock No. 17 on the Warrior River field work and surveys had been carried out prior to the completion of that work as follows:

Bench-Mark levels from "mean-tide" Mobile Bay were established and extended from Lock No. 16 up the river beyond and above the backwater on both Mulberry and Locust Forks.

Complete topographical maps with 5-foot contour intervals were made from surveys covering the entire basin of submergence.

The surveys are usually made to the tops of river banks, but in some cases have only been extended for one contour above pool level.

Careful and detailed topographic and geological surveys of the sites for locks, dam and appurtenances which receive the careful study and investigation which their importance demands.

In making the traverse of the banks and bed of the Warrior and its tributaries, all lands liable to submergence were carefully mapped, tied in with section corners, and in many cases were photographed. Some cultivated lands have been submerged. Property of this kind received the most careful attention on the part of the government engineers, photographs being made of all structures, and of various divisions of the land, three photographs from different viewpoints being taken of each structure or piece of land.

Outside of the sites for dams and locks, the government purchases little land until after the completion of the work of actual submer-

gence of the same. Along the navigable streams the ownership of the banks is often a mooted question, because of the difficulty of establishing high, low and normal flow lines.

While it is the policy of the government to be fair and even liberal in its acquirement of such lands, frequently the small and ignorant property owner becomes the victim of unscrupulous lawyers and land grabbers. These rascals go to such owners and tell them that the government intends to submerge a large part of their land; that they can not sue the government, and that the balance of their land will be uninhabitable after the dam is completed on account of malaria, etc. By such misrepresentations lands have been recently sold around the pool created by the dam at Lock No. 17. These lands are all underlaid with coal, and in most cases the mineral value per acre far exceeds the surface value.

In view of the vast interests involved in connection with the construction of these impounding reservoirs, including the questions of public health, regulation of stream flow and navigation, utilization and conservation of natural resources, security for investors and all other economic questions, the importance of systematic physical and zoölogical surveys of the site and neighborhood of any proposed impounding basin must be apparent.

Such surveys have not been made in the past or in connection with any known basin so far as the writer is informed. Had such investigations been made before the building of a number of large dams in this state and in the Carolinas the litigation pending would have been avoided.

Dr. Carter says:

> Since we wish to determine the whole effect of the pond on the production of malaria, we must compare the condition which existed before the pond was made with that which exists afterwards. If the malaria which the pond produces be counted a debit, the malaria it prevents must be counted a credit. It is the *change* in conditions we would know.

The physical survey should include all the field work required for the production of a complete record of the topographical, geological and botanical characteristics of the site intended to be submerged as well as the surrounding neighborhood.

The maps of these surveys should be made under the direction of an expert cartographer familiar with the methods of map construction and the conventional signs commonly employed. He should

be possessed of such actual knowledge of map making as is only gained by practical experience in field surveying of this class. He should be able to distinguish between the quality and value of the various symbols. These maps should clearly show the location of all pools, marginal wet lands or actual breeding places and the areas of such places together with the location of all temporary or permanent breeding places on tributary streams or neighboring lands.

The physical survey of the site should include careful investigations to determine whether the places examined are such as would make them favorable breeding places for Anopheles, and if so, are they so situated as to produce malaria; to determine what places are actually breeding malaria-vectors; to make a careful survey of all residences close enough to be influenced by any proposed constructions; the distances from such residences and any obstacles between the place examined and such residences; character of the water, vegetation, protection against wave action, floatage, proximity of blood supply, etc.

The Zoölogical Survey will take account of whether Anopheles or other mosquitoes are found breeding in any place and to what extent; the species of Anopheles, whether or not a malaria-vector; the presence of fish and other aquatic enemies; a careful study of and classification of Anopheles or other mosquitoes found about the premises of adjacent residences to proposed site and in the neighboring tributary streams or breeding places.

The sanitary survey should include a careful investigation of all health records of all people living in the community or within reasonable range of the proposed reservoir including blood examinations and a complete malarial index of the neighborhood or community. In this connection it is believed there will be little trouble experienced in securing the active coöperation of the board of health since the importance of these investigations is now so well understood.

DISCUSSION

Mr. W. F. Wilcox: The speaker does not think discussion on the subject of "Impounded Waters" would be of any value to you unless you had at hand your data so as to show what the result was. We have a lake 7 miles long, varying in depth from zero to 80 feet. We keep close watch of this reservoir, having a chemist in charge who makes chemical analyses of the water, both mineral and bac-

teriological. We keep a record of the temperature of the water, taking this temperature at least once a week, also the humidity and the velocity of the wind.

One of the difficulties that we have to contend with is that at the head of the lake about 6,000,000 gallons of sewage empties. That sewage has been filtered before it is turned into the reservoir. The amount of purification that will take place in an impounding reservoir in such a case is remarkable. Our analyses show that as the water deepens and is allowed to run the purification is quite beyond our expectations. A discussion of impounded reservoir waters is not of any value unless you have detailed data. The speaker has such data for five years, and if any of you want any information at any time, he will be very glad to answer your questions; but offhand discussion without detailed data he does not think is of any value.

The speaker wishes to say that this reservoir that he has charge of is not for drinking water, it is for mechanical purposes; but we have been able to purify the water to such a degree that it meets the chemical and bacteriological standards. If it were not for the history of the water, we could easily palm it off as a very sanitary drinking water.

PRESENT STATUS OF DISINFECTION OF WATER SUPPLIES

By Francis F. Longley

The treatment of water by disinfection has had a remarkably rapid growth and has come to be a popular and widely known subject. So much has been written and said upon this in the last few years that it is with some hesitation that the writer approaches the subject. In most phases of it there is danger of a great deal of repetition. There are a number of points, however, upon which recent occasion has arisen to make rather extended inquiry, and the following is intended to embody some of the results of this study.

This information was brought together through the circulation of a large number of inquiries intended to cover the field of disinfection in reasonable fullness. A list of the water supplies in the United States and Canada, in which some method of disinfection was known or believed to be used, was prepared from all available sources. Although the hearty coöperation of engineers, health officers and others was secured in a great many cases, there can be no assurance that the list was complete.

The total number of inquiries sent out was about 240. Replies were received to about 110, or nearly half. These replies represent in the aggregate water supplies of somewhat more than 2000 million gallons per day.

The information is given herein largely in statistical form, and, of course, relates only to the supplies regarding which replies were received.

Some of the inquiries were directed at the less used methods of sterilization, such as ozone and ultra violet rays, but so little information in reference to these was forthcoming that the writer is not disposed to say anything further in regard to them herein than that their development is not far enough advanced at the present time to justify the expectation of success in the near future which will permit them to displace the use of hypochlorite and liquid chlorine to any considerable extent.

Of all the replies received about 80 per cent are stated to use, or to have used, hypochlorite of lime, and the balance liquid chlorine.

About 75 per cent of the supplies regarding which information was received are river waters; about 20 per cent are from lakes, and the small remainder are ground waters.

The first application of hypochlorite noted among the replies was in 1908, in which year disinfection by this means was begun at the Bubbly Creek plant at the Union Stock Yards in Chicago; at the Boonton reservoir of the Jersey City supply, and upon the municipal water supply of Poughkeepsie, New York. The several years following showed a rapid increase in the number of installations, although the records of 1913 indicate a falling off. The rates for the year 1914 are incomplete. Of the total installations regarding which replies were received, the percentages installed each year have been as follows:

1909, 13 per cent, representing a total of 100 million gallons per day.

1910, 14 per cent, representing a total of 450 million gallons per day.

1911, 22 per cent, representing a total of 320 million gallons per day.

1912, 22 per cent, representing a total of 710 million gallons per day.

1913, 18 per cent, representing a total of 70 million gallons per day.

1914, 8 per cent, representing a total of 265 million gallons per day.

Some 37 per cent of the cities replying use a disinfection without other treatment. The balance use it as an adjunct to some treatment, in most cases filtration. In 57 per cent of those cases in which it is used as an adjunct to filtration, it is used as a final treatment. In 26 per cent it is used after coagulation or sedimentation and before filtration. In the remaining 17 per cent it is applied before coagulation and filtration.

The data at hand do not give any reasons for the application before coagulation. In general, an effective disinfection may be secured with a smaller quantity of hypochlorite if it is applied after rather than before filtration. It should be noted that the storage of chlorinated waters in coagulating basins and their passage through filters tend to lessen tastes or odors contributed by the treatment,

and this fact may in some cases account for their use in this way. Beyond this there is nothing in the moderate amount of bacterial data secured in connection with this work that enables us to generalize upon the relative advantages of these different points of application.

The cost per million gallons for the equipment required for this treatment varies widely and does not seem to bear any very close relation to the capacity. The cost per million gallons as stated, varies all the way from \$4 to \$2400. These variations are accounted for by the fact that designs for equipment of this sort vary widely. Some are the merest makeshifts, while others are elaborate. Some of the costs quoted include no building costs, while others include expensive structures. Taking the figures as they stand, as the data do not permit any further analysis, the total costs per million gallons are stated not to exceed \$25 in 12 per cent of the supplies, \$50 in 30 per cent, \$100 in 42 per cent, \$250 in 67 per cent and \$500 in 87 per cent of the supplies about which information is available.

The total cost per million gallons for the process also varies widely. By far the greater number of costs stated lie between 10 cents and 50 cents per million gallons, the average for these being about 25 cents.

The information at hand indicates that the commonest construction of tanks for hypochlorite is concrete. Some 67 per cent of the supplies stated that they had either concrete tanks or tanks of wood or iron relined with concrete. Something more than 20 per cent are of wood without lining. The balance are either wood with lead lining, wood or iron with some protective or acid resisting paint, or porcelain lining. The liquid chlorine is universally contained in special iron cylinders.

The piping seems in general to have been put together of the materials most easily available, without regard to corrosion. Fifty-six per cent of the replies indicate the use of iron pipe, either black or galvanized, 15 per cent use lead pipe and about an equal number use brass. A few use lead-lined iron pipe, cast iron pipe, hard rubber, rubber hose, bronze or copper pipe.

The same comments apply to the kind of valves and fittings commonly used. Sixty-six per cent of these are of brass such as are usually found in stock. Some 14 per cent state that bronze valves and fixtures are used, but it is possible that some, if not most of these, upon further inquiry, might prove to be brass. A few use

iron valves or fittings and a few have fixtures made of vulcanite, rubber composition, lead, copper, glass, etc.

The materials commonly used which seem to have shown the greatest resistance to the corrosive effects of hypochlorite are concrete tanks, lead pipe and rubber composition. Several of the answers indicate that copper, cast iron and lead-lined iron pipes are used without corrosion and a number indicate, too, that brass and galvanized iron are used without corrosion. The evidence as to these two last materials, however, is contradictory, as other answers indicate considerable corrosion with galvanized iron and brass. It seems likely that the quality of the material and some peculiar local conditions may, perhaps, be determining factors in the corrosive effect upon these two materials. The results show the unmistakable corrosive effect upon wrought iron and also upon wood.

Evidence has been found in the past of occasional large variations in the strength of commercial hypochlorite. In answer to an inquiry on this point, only 29 per cent indicated that the strength of hypochlorite as purchased had been determined. That this is a point of considerable importance is indicated by the following figures:

The maximum percentage of available chlorine stated was 42 per cent. Numerous others ran as high as 39 or 40 per cent. The minimum stated was 15 per cent, with several others less than 20 per cent. The average strength was 33 per cent. In two cases the maximum percentage strength noted is as large as 2½ times the minimum strength. These variations in quality in the commercial hypochlorite are significant, and it is obvious that the strength should be determined and a correction made in the application, if necessary, if the best results are to be secured.

The low cost and the ease of application of disinfection to water supplies have caused its introduction in a great many places where the records of mortality or morbidity from such diseases as typhoid, which can be used as indicators of the benefits derived, are already so low that no striking improvement can be expected therein. In a large percentage of the cases it seems clear that the application was as a precautionary measure. This fact makes it less easy than might be expected from the large number of cities and towns making use of disinfection to present statistics showing actual benefits resulting therefrom. Among the large number of communities from which information was obtained, about 75 per cent failed to indicate that any improvement in typhoid or other health condition had resulted.

Many of these indicated that no such improvement had been expected. In some cases where there has been an improvement, it is difficult or impossible to discriminate between the effects of disinfection and of filtration.

The following statements show improvements that have resulted in a number of places:

In Cleveland, Ohio, the chlorination of the water supply started in September, 1911. In the six calendar years prior to this the typhoid death rates had varied from 13 to 20.2, with an average of 16.5 per 100,000. In the three calendar years following, the typhoid death rates were from 6.2 to 13.5, with an average of 9.2 per 100,000.

In Yonkers, New York, the analyst in charge of the water supply states that prior to the use of hypochlorite, but with the water filtered through sand filters, two epidemics of dysentery were recorded at times when the water was unusually high in bacteria. Disinfection by means of hypochlorite was put in use early in 1910. Since that time there have been no such excessive bacterial counts and no corresponding epidemics of dysentery.

In Evanston, Illinois, there has been an actual reduction in intestinal diseases, indicated by the statistics of typhoid fever and gastroenteritis, which appears to have resulted from the application of disinfection. This was first applied in December, 1911. The statistics at hand cover the period of four years prior to this, namely, 1908 to 1911 inclusive; and three years after, 1912, 1913 and 1914. The death rate from typhoid in the former period varied from 24 to 33, averaging 29 per 100,000. In the period since disinfection it has varied from 6 to 15, with an average of 12. The death rate from gastro-enteritis during the former period varied from 25 to 73, with an average of 49 per 100,000, and in the latter period with disinfection varied from 11 to 40, with an average of 30.

In the city of Baltimore there has been a decided reduction in the typhoid mortality since the use of calcium hypochlorite. It was first used in June, 1911. In the five years prior to that, the death rate from typhoid varied from 33 to 42 per 100,000, with an average of 35. In the three years since, it has varied from 22 to 24, with an average of 23.

In Poughkeepsie the disinfection of the supply was first begun in 1908 in the form of hypochlorite applied to the water before sedimentation and filtration. The death rate from typhoid fever for eight years prior to 1908, as indicated by the United States census

reports, varied from 25 to 114, with an average of 54 per 100,000. From 1908 to 1913, with treatment as stated above, the typhoid death rate varied from 10.3 to 33, with an average of 18.5. Since early in the year 1914 the filter effluent has also been treated, first by means of hypochlorite, and latterly by means of liquid chlorine, and the death rate from typhoid fever for that year was 3.4 per 100,000.

Trenton, New Jersey, is one of the most striking cases of improvement due to disinfection. Prior to 1912 the city used the raw Delaware River water. In December, 1911, the authorities commenced to treat the water supply with hypochlorite. During the five years ending with 1911 the annual number of typhoid cases varied from 208 to 343, with an average of 267. During the three years since disinfection has been applied, the number of cases in the city has varied from 45 to 110, with an average of 74.

In Ottawa the water of the Ottawa River was used without treatment until about March, 1912. Its polluted condition was evidenced by the several epidemics of water-borne typhoid that the city had been through just prior to that. Since the disinfection of the supply, Ottawa has had no further epidemics and only a moderate death rate from typhoid.

The city of Hull, with only about one-twentieth the population of Ottawa, lying on the opposite bank of the river, takes its water supply, untreated, from the same channel as does Ottawa and within a few hundred yards of it. In two recent months Hull has had about 200 cases of typhoid fever, as against 28 in Ottawa for the same period.

In Centralia, Washington, during the winter of 1913 and 1914, there was a sharp epidemic of typhoid fever, due apparently to the pollution of a well supply by overflow of a stream which is known to have carried pollution. A hypochlorite plant was hastily installed and put in operation and this was followed by a quite definite and abrupt cessation of new cases of typhoid, since which time there have been no cases in Centralia, with the exception of certain hospital cases brought in from outside the community.

The results of hypochlorite treatment in Pittsburgh have indicated an improvement in typhoid conditions over and above that secured by filtration alone.

Hypochlorite was first applied in November, 1911. In that month there were 54 cases, in December 42, in January, 1912, there

were 20, and in February 5. From that time forward, the cases have remained for the most part less than 10 per month and have never again approached the high points of previous years. It is rare for the present high points to reach the former low points of the curve.

In Wilmington, Delaware, the excellent protection which disinfection affords was shown at the time of an epidemic of typhoid fever of about 250 cases at Coatesville, Pennsylvania, some 27 miles above Wilmington, upon the stream from which Wilmington draws its supply. The epidemic made its appearance in Wilmington, but was stopped short by the disinfection of the water supply.

The maximum dose of hypochlorite stated is 60 pounds per million gallons, which is at the Bubbly Creek plant in Chicago, where the nature of the water treated is well known to require a large dose. The lowest maximum quantity stated is 4 pounds per million gallons. The average of all the maximums stated for the various plants is 17 pounds per million gallons.

Bubbly Creek also shows the highest average dose of 55 pounds. The next highest is 35 pounds, and the lowest average dose stated is 3 pounds. The average of all the averages stated is about 11 pounds per million gallons.

Judging from the lack of information in response to inquiries bearing upon the relation between the quantity of hypochlorite required and the color or turbidity in the water, it seems that a surprisingly small amount of attention is given in the various cities to following out this relationship. A knowledge of this relation is of some importance, as it influences the quantity of hypochlorite that is required for a given water, the quantity that may be applied without producing objectionable tastes and the economy of the treatment.

The reason for the lack of attention to this point seems to lie in the fact that the cost of the hypochlorite required for any water is trifling and it is not of great importance just what quantity is applied, so long as it is enough, on the one hand, to give good bacteriological results, and, on the other hand, not so much as to produce objectionable tastes and odors.

The doses that fulfill these two conditions do not always coincide. The character of some waters is such that the dose which can be applied without contributing objectionable tastes and odors is more than enough to produce the desired bacterial reduction. With such

waters there is no difficulty in regulating the dose to give satisfactory results from every point of view. The character of other waters is such that the maximum dose which can be used without giving a taste is not enough to give the bacterial reduction required. This is the difficult condition to meet, and is found more frequently in raw waters than in filtered waters.

It is everywhere recognized that there are certain times when the hypochlorite treatment is less satisfactory than at others. This is shown principally in the appearance of tastes and odors that occasion complaint among consumers, or in a low and unsatisfactory removal of bacteria by the treatment. It occurs generally at a time when the turbidity or the color of the water increases greatly, or some other marked change, such as temperature, occurs in the condition of the untreated water.

Different waters vary a good deal in this respect, and but little information can be found which gives light upon the specific reasons for this variation and permits the formulation of general statements in regard to it.

An analysis of the figures at hand shows that in one place a maximum dose as great as 37 pounds per million gallons has not given rise to objectionable tastes or odors, and in numerous places 20 to 30 pounds has not been noticeable. The average amount stated for which no odor or taste was noticed was about 14 pounds per million gallons. The supplies in which it was definitely stated that no tastes or odors were noticeable included about 40 per cent of the total. Among the others there were general comments as to the occurrence of objectionable tastes or odors, indicating in the main that they are likely to occur with changes in the character of the water treated, especially at times of storm or freshet.

So far as is indicated by the somewhat incomplete data, the largest quantities of hypochlorite are used in those supplies in which the color or turbidity of the water are highest. Unfortunately, the information is not complete enough to enable any relationship to be established even in an approximate way between color, turbidity and quantity of disinfecting agents that may be used without objection.

DISCUSSION

Mr. C. A. Jennings: About two years ago the speaker had a paper along the same lines before the Illinois Water Supply Association, and quoted statistics on typhoid death rates from a number of cities. The criticism was made of the paper at that time that the typhoid fever death rates were taken for periods anywhere from four to twelve years previous to the introduction of the disinfecting agent, and the typhoid data for only two or three years following—that is to say, whatever data were available since the introduction of the disinfectant were used. The point was made that great progress had been made in sanitation in the last few years, and that it did not give a fair comparison. If that criticism held in that paper it will also hold in Mr. Longley's paper. It may be well to weigh carefully the data received and not be too ready to place all of the credit to one charge. However, there is no argument against the statement that disinfection of water supplies has brought about a wonderful lowering of typhoid fever death rate, especially during the last four or five years.

Mr. Wm. M. Jewell: The speaker has been very much interested in Mr. Longley's paper, and it seems that he has covered the statistics very well from a general standpoint, but he has not given the details that we need for laying out these works at various plants; in other words, the information is very general.

At Chicago, where the hypochlorite is used at one of the stations, it was found that about five or six times more hypochlorite was required for the sterilization than they could stand for, probably on account of the low temperature of the water; and that is a very important point that ought to be investigated by members of this section. It would be a good thing to have a committee on those features to report at the next meeting in order that the physical characteristics of introducing hypochlorite can be properly complied with. The members here would certainly like that information; those that are putting the plants in at least.

The paper states that the first use of hypochlorite was in 1908. In that connection will say that at the filter plant installed at the city of Adrian in 1897, the speaker used both hypochlorite of lime and sulphate of alumina, and prior to this chlorine gas was used on the testing plant.

Hypochlorite of soda and chlorine were first used on the Jewell filter at the Louisville Experimental Station about one year earlier, or in 1896; reference to Mr. Geo. W. Fuller's report of 1898 will substantiate this statement.

Mr. M. B. Litch: Will Mr. Jewell please state just what he meant by more than what the water could stand for?

Mr. W. M. Jewell: That is the statement that Mr. McDonough, the assistant commissioner of the public works, used, and presumably related to the odor, or the taste rather, if you can differentiate between the two in the case of hypochlorite of lime any more than you could with peppermint. He stated that at times of low temperatures the hypochlorite seemed to be undecomposed, and that therefore they could not get rid of the Coli; the amount used was five or six times more than was required under ordinary conditions of normal temperature at which times excellent results were obtained and the odor or taste, if any, would not be noticeable. Possibly there is a point, probably somewhere below normal temperature of the lake water, where the hypochlorite can be used efficiently and no odor or taste imparted to the water; whereas on the same water at a slightly lower temperature, such objections would exist and cannot be combated; at least in the light of our present knowledge of the way of using hypochlorite.

Mr. H. P. Letton: In 1911 Trenton, New Jersey, began to treat raw Delaware River water with hypochlorite. The state board of health carried on a series of examinations for the purpose of determining the proper dosage. At that time, which was during the winter, the water was cold and very high in turbidity and organic matter. The dose of chemical added was run up as high as 30 pounds per million gallons. Samples of the treated water taken an hour after the addition of the chemical, and tested for free chlorine, all gave negative results, although the water had an extremely disagreeable taste, and this taste persisted throughout the entire distribution system, and was especially noticeable in the hot water. The steam arising from a flowing hot water tap had a very strikingly unpleasant odor. From the tests made the conclusion was reached that the taste and odor were not those of the chlorine, but were due to some complex chemical change brought about by the action of the chlorine

on the organic matter present in the water. There was more or less complaint about the taste and odor at the time, but, as Mr. Longley's paper has shown, the chlorine treatment at Trenton reduced the typhoid death rate to a remarkable extent. A report on the tests mentioned and some statistical data regarding the effect of the treatment will be found in the 1912 report of the New Jersey state board of health.

Mr. R. L. Sackett: In the state of Indiana there is quite a wide variation in the geological conditions, which has permitted the smaller cities in the northern part to use well waters, but in the southern portion well waters are rare, and they have therefore quite generally used the surface waters of the Ohio River Valley. These waters are polluted in greater or less amounts. Some cities in Indiana have for several years been using water supplies for fire protection and street sprinkling purposes only, and not using them for culinary purposes. The state board of health found a portable apparatus for the installation of hypo treatment to be very valuable, and have equipped their laboratories with these simple temporary pieces of apparatus, which can be sent out to the smaller cities, and there hypo has been used, too much at times, and undoubtedly at other times too little, in cities where the water supply was without treatment at all, or where it was not satisfactory. These plants are inexpensive of course. They are manually controlled, and the question of the cost of hypo was not important. Very frequently the odor and taste of hypo were objectionable, but not so objectionable as the conditions which preceded it, and unquestionably this plan of the state board of health of placing in cities, practically without expense, as a temporary measure, these simple schemes for treatment with hypo has been of great value.

It is very difficult to collect data concerning the absolute influence upon mortality and morbidity, but the state board of health has been pretty well satisfied with its little propaganda, and feels that it has been of value. Many of these smaller cities have very gratefully accepted the tastes and odors as being the lesser of the evils until they could install better apparatus for the protection of their water supply.

Mr. John A. Kienle: Mr. Jewell's remarks regarding the effect of the temperature of the water at Chicago producing taste and

odor recalls to the speaker's mind the conversation with the gentleman mentioned by Mr. Jewell, namely, Mr. McDonough, assistant mechanical engineer of the department of public works, and the speaker wishes to throw a little light on this subject.

In conversation Mr. McDonough stated that when the temperature of the water is down around 38° or 40° they are compelled to materially reduce the amount of hypo being applied. However, on numerous occasions, it was stated that the taste and odor prevalent in the city tap water were not due to an excessive quantity of hypochlorite actually being applied. In Chicago the application of hypo is made at the intake cribs, which are located a considerable distance out in the lake and the direction of the winds, as well as the state of the lake, due to these winds, necessitate the holding of the sludge in the tanks for a considerable length of time. This sludge sometimes accumulates to such an extent that they are compelled to dispose of it even under adverse conditions. At such times the action of the waves and the winds causes this sludge to be blown back into the crib and down into the shaft and tunnel. The result is a very noticeable taste and odor in the tap waters of the city fed from these particular cribs with the natural complaint from the citizens.

The writer believes that quite a little of this sort of trouble in Chicago has been due to the fact that close supervision could not be given to the operation of the hypo plant. In some instances there is not even telephone communication with the cribs. Under these conditions it is naturally to be expected that the attendants in charge of the hypo treatment are not familiar with the conditions prevailing in the city, and therefore cannot be quickly advised as to the best amount of hypo to be applied.

The question of temperature of the water also has its effect in other places; this being particularly the case at Milwaukee where the speaker is familiar with the operating conditions. In this city they normally apply during the spring, summer and fall months of the year, about six pounds of hypo per million gallons, but as soon as the water temperature goes down to about 40° they are compelled to cut the dose applied to as low as 3 pounds per million gallons; this being necessary in order to prevent taste and odors prevailing in the tap waters. At the times when this decreased dose is applied the bacteriological count runs up considerably and it is due to this fact, as well as the desire to prevent taste and odor, that

the use of liquid chlorine was recommended and a liquid chlorine plant recently installed.

It is rather difficult to give an absolute reason for the prevalence of taste and odor in these low temperatures following with application of hypochlorite of lime, except that it may possibly be due to the nondecomposition of the chloride solution. This is a chemical compound and it naturally has to be broken down in order to accomplish its bactericidal action, and if it is not broken down then the chlorine is carried right through with the lime and is undoubtedly responsible for the taste. It is a known fact that chloride solution will not readily decompose in water at low temperatures.

The question of organic matter affecting the taste and odor, the speaker believes is one that should be given careful consideration. In a great many cases where taste and odors prevail they are due, not to the liquid chlorine or to the hypochlorite, but to the decomposed vegetable or organic matter in the water. This was the case at East Chicago and the speaker knows of other similar instances, and he further believes that the nature and character of the organic matter in the water also have a decided effect on this question of taste and odor.

As an example he would cite the following: At the Notre Dame de Grace, District of Montreal, they have a rather peculiar condition of this kind. The water at this station is taken from the St. Lawrence River just below the junction of the Ottawa River with the St. Lawrence. During the winter months nothing but St. Lawrence River water reaches the intake of the station, yet when the spring freshets prevail the Ottawa River water rises very materially and the current from it is swept across the St. Lawrence into the intake of the pumping station. The Ottawa River is of an entirely different character from that of the St. Lawrence. It is a water that is quite high in color and in organic matter. It does seem, however, that the nature of this organic matter must be quite different from that which would be found in other waters. This is evidenced by reason of the fact that at this station they are applying liquid chlorine and when treating the St. Lawrence River water approximately four-tenths parts per million of available chlorine are required for sterilization. As soon as the Ottawa River water reaches the intake they are compelled to apply as much as one and one-half parts of chlorine per million, yet even with this high dose no taste or odor prevails.

In the operation of this plant sufficient chlorine is applied at all times to the intake so that they get a KI reaction on a sample of tap water taken from the discharge of the pump. The liquid chlorine, however, appears to be entirely dissipated by the time it has traveled several hundred feet from the station as no KI reaction can be obtained on samples taken at this point.

Dr. D. P. Curry: At Bowling Green, Kentucky, there were tastes and odors. At the plant they had but one mixing vat. The operator would start his pump and stirring device at the same time, pumping the sludge and all into the mains. At that time they were doing some work on the mains, and there was considerable disturbance of the sediment in them. The odor and taste of the hypo were extreme. Was not this due to using the milky mixture rather than the sedimented clear solution?

Mr. John A. Kienle: Regarding the last gentleman's remarks the speaker would say that at Pittsburgh they are applying the hypochlorite powder directly and in a very crude way and so far as he knows excellent results have been obtained without the prevalence of taste and odor. In other words, at this plant they do not attempt to take out any of the sludge or even settle it. The application is made simply by shoveling the powder into the water of the clear well at regular intervals. This therefore is one instance where the sludge does not worry them apparently.

Mr. H. P. Letton: The speaker knows that a year or two ago the East Jersey Water Company, at their filtration plant at Little Falls, New Jersey, treated the filtered water with hypochlorite, which was fed in as a milky solution, the lime being kept in suspension by a stirring device. No tastes or odors resulted from this practice.

THE MANUFACTURE OF SULPHATE OF ALUMINA AT THE COLUMBUS WATER SOFTENING AND PURIFICATION WORKS

By Charles P. Hoover[1]

A plant for making alum has recently been built and put in service at the Columbus water purification plant. This is the first plant of its kind ever built at a water purification works for making alum to coagulate water, and, although it has only been in operation a short time, it has been a success both technically and economically.

An investment of $12,000 was required for its construction, and it has been conservatively estimated that $6000 per year will be saved the city in the cost of alum. Between 800 and 1000 tons of alum will be manufactured during the coming year at a cost of about $10.50 per ton.

The process most generally employed today for coagulating and purifying water contemplates applying to the water under treatment a solution of aluminum sulphate prepared by dissolving in water the previously crystallized chemical.

In order to show the advantage of the new process, as used at Columbus, and to point out the advantage of making alum at the point where it is to be used, a brief explanation of the old process of making alum for water purification purposes will be necessary.

OLD PROCESS FOR MAKING ALUM FOR WATER PURIFICATION PURPOSES

Lump alum or sulphate of alumina is a combination of bauxite (a southern clay containing from 58 to 60 per cent alumina, the aluminum being present $Al_2O_5H_4$) with sulphuric acid (H_2SO_4). By mixing the two in lead lined tanks, and boiling for a period of from 6 to 8 hours, the first step in making alum is taken.

The following reaction takes place between the bauxite and acid.

$$Al_2O_5H_4 + 3H_2SO_4$$
$$Al_2(SO_4)_3 + 5H_2O$$

[1] Chemist, Columbus, Ohio, Filter Plant.

The resultant solution is a mixture of aluminum sulphate and silica, and in order to obtain the clear aluminum solution it is necessary that the mixture be filtered.

The filtering process is perhaps the most costly, tedious and annoying step in the whole process of alum making, because the finely divided particles of silica present in crude sulphate solution quickly clog the pores of the filtering medium, and it is often necessary to force the material through the presses under considerable pressure. After being filtered the alum solution is boiled to expel the excess water. The expense of concentrating the syrup must be taken into consideration, because it is concentrated from a density of between 25° and 30° Baumé to a density of between 58° and 60° Baumé. After being concentrated the solution is discharged into trays, and, on cooling, crystallizes to the alum cake. The alum cake is then crushed or pulverized and shipped either in bulk, in barrels, or in sacks. The material, after being received at a water purification plant, is usually dissolved as needed, and a standard strength solution prepared, this solution being fed by a suitable measuring device into the water to be purified or treated.

THE HOOVER PROCESS

Bauxite and sulphuric acid are boiled in lead lined tanks until a basic solution of aluminum sulphate is obtained. The solution is then diluted with water, usually enough water is added to make 500 gallons of the solution equivalent to one ton of 17 per cent Al_2O_3 alum, and measured as needed into alum solution tanks, where it is diluted with sufficient water to make a standard solution, which is then applied to the water under treatment. By this process five distinct steps in alum making are eliminated, namely, filtering, concentrating, crystallizing, grinding and redissolving. This process is a much shortened process, being simple and inexpensive, because it consists simply in boiling bauxite with sulphuric acid and applying the resultant solution to the water under treatment.

DEPOSITION OF SLUDGE OR CHEMICAL MUD

The crude alum solution containing silica or other inert material from the bauxite, probably better defined as chemical mud, is applied to the water under treatment, the chemical mud mixes with the mud or suspended particles present in the water and finally be-

comes entrained or coagulated by the precipitated aluminum hydrate and settles out in the settling basins. The crude solution, containing the chemical mud in suspension until the metallic sulphate has been converted into hydroxide, has a function not possessed by alum solution prepared by the old process, namely, forming a matrix or nucleus for starting the coagulation, resulting not only in more efficient results with less coagulant, but also affording the process universal applicability irrespective of any lack of natural turbidity.

BAUXITE[2]

The first discovery of bauxite in America was in 1887 at a point a few miles southeast of Rome, Georgia. At present the known workable deposits of bauxite are limited to a few localities in Europe and the United States. Its occurrence in Europe is in France, Germany, Austria and Ireland; and in the United States, in Georgia, Alabama, Arkansas and New Mexico.

The mining of bauxite in the southern states has shown a great growth during the last few years. The annual production passed the 150,000 long ton mark in 1911. The production of bauxite in the United States from 1900 to 1911, inclusive, is shown in the following table.

YEAR	GEORGIA AND ALABAMA	ARKANSAS	TOTAL	VALUE
1900	19,739	3,445	23,184	$89,676
1901	18,038	867	18,905	79,914
1902	22,677	4,645	27,322	120,336
1903	22,374	25,713	48,087	171,306
1904	21,913	25,748	47,661	235,704
1905	15,173	32,956	48,129	240,292
1906	25,065	50,267	75,332	368,311
1907			97,776*	480,330
1908	14,446	37,703	52,167	263,968
1909	22,227	106,847	129,101	679,447
1910	33,096	115,836	148,932	716,258
1911	30,170	125,448	155,618	750,649

* Production of Tennessee included.

[2] From Geological Survey of Georgia, Bulletin No. 11.

Mining of bauxite

As a rule it is very easy to mine because of its comparative softness beneath the surface, it being soft enough in most cases to be dug up with a pick, although black powder is sometimes used to loosen it from its position. The bauxite is usually removed in steps or benches, and loaded into small mine cars. The ore contains a large percentage of uncombined water, which, unless expelled or driven off before shipment, makes it an important factor in the freight cost. The ore after being crushed is passed through long rotary kiln driers, similar to rotary cement kilns.

Three grades of ore are mined, first, that used in the manufacture of metallic aluminum; second, that used in the manufacture of alundum, and third, that used in the manufacture of aluminum salts.

On account of the strict specifications drawn for sulphate of alumina, by those in charge of water purification plants and paper mills, only the ore containing less than 2 per cent of ferric oxide (Fe_2O_3) is used in making aluminum sulphate. The more ferruginous ore is used in the manufacture of metallic aluminum, and the very purest grade of ore is used for the manufacture of alundum.

The following was taken from Bulletin No. 11, Geological Survey of Georgia:

> The possible yield of bauxite is greatly limited by the fact, that nearly all but the first grade material is discarded; thereby necessitating the exclusion of a vast quantity of ore, which should, by proper skill and manipulation, find ready utilization at good prices. This condition was, perhaps, made necessary in the beginning, when markets had to be established, in order that home material might compete with the cheap and less pure foreign bauxites of long standing and reputation. The principle has been so rigidly adhered to, by both operator and consumer, during the period of working in the American fields; that it has resulted in creating a demand for the first grade ore only, with practically no sales for the lower grade bauxite.

The writer believes that it is not necessary to demand bauxite of highest purity for making of aluminum sulphate to be used for water purification purposes, and it seems entirely possible that much of the cheaper grade bauxite could be used to advantage in making alum for water purification purposes.

SPECIFICATION FOR BAUXITE USED AT COLUMBUS

The specifications for bauxite now used at the Columbus plant are as follows:

Bauxite to be crushed and dried to contain not over 3 per cent moisture, the analysis to be:

Al_2O_3 not less than 52 per cent.

Fe_2O_3 not more than 3 per cent.

The contract for furnishing the supply needed for the period ending July 1, 1915, was awarded at $5.50 per ton, 2240 pounds, f.o.b. Bauxite, Arkansas. The freight rate from Bauxite, Arkansas, to Columbus, Ohio, is $4.40 per long ton, therefore, a ton of 2000 pounds delivered to Columbus, Ohio, costs $8.84.

Bauxite contains from 58 to 60 per cent Al_2O_3, whereas, ordinary filter alum usually contains 17 per cent Al_2O_3, therefore, one ton of bauxite will make a little more than three tons of alum ($Al_2(SO_4)_3$ $14H_2O$).

Bulletin No. 11, Geological Survey of Georgia, published in 1904, lists the following companies as either owning or working bauxite deposits in Georgia:

The Republic Mining and Manufacturing Company.

The Georgia Bauxite and Mining Company.

The Dixie Bauxite Company.

The Southern Bauxite Mining and Manufacturing Company.

Dealers known to the writer who are in position to quote prices on bauxite are:

Aluminum Company of America, Pittsburgh, Pa.

Mr. Winthrop C. Neilson, 1111 Harrison Building, Philadelphia, Pa.

National Bauxite Company, Philadelphia, Pa.

Globe Bauxite Company, Joliet, Ill.

HALLOYSITE

Good filter alum may also be made from halloysite. The approximate chemical analysis of which is as follows:

	Per cent
Soluble alumina	38
Insoluble (silica, etc.)	40
Water	22

Several manufacturers have attempted to make crystallized alum from halloysite, but have failed, because it has been found almost impossible to filter or separate the insoluble portions of the halloysite from the aluminum sulphate syrup. At the Columbus water purification plant, one tank, equivalent to about 6 tons of alum, has been made and used and the results obtained show that aluminum sulphate can be made from halloysite by the process being used at the Columbus water purification plant. Several carloads of this material have been purchased, and further experiments with the use of halloysite as a base for making alum solution will be made.

The North America Chemical Company, with offices at Urbana, Ohio, have a very large deposit of this ore, estimated to be 15,000,000 tons, located near Rome, Georgia, and they have assured the writer a number of times, that if a market can be created for halloysite, the material can be furnished f.o.b. cars, Rome, Georgia, at approximately $2 a ton.

SPECIFICATIONS FOR SULPHURIC ACID

Sulphuric acid, to be used for making alum, is contracted for, at the Columbus water purification works, under the following specifications:

The sulphuric acid shall be that known as 66° Baumé contact process acid, and shall contain not less than 92 per cent H_2SO_3.

The material shall be delivered at a uniform rate of not less than 30 tons per month, or at such increased rate as shall be directed.

The sulphuric acid shall be shipped in acid tank cars, provided with all necessary connections for removing the acid from the car by air pressure. Each tank shipment not to contain more than 30 tons of sulphuric acid.

Each tank car lot as a unit shall be the basis for accounting for determining of the amounts payable to the contractor.

GENERAL DESCRIPTION OF PLANT

The plant comprises: 2 lead lined boiling tanks, 2 alum measuring tanks, 1 acid measuring tank, 1 sludge tank, 1 storage tank for sulphuric acid, 1 crusher for crushing bauxite, 1 pulverizer for pulverizing bauxite, conveying, elevating and transmission machinery, bauxite storage bins and weighing device, piping, valves and fittings.

COST OF OPERATION

The following is an estimate of the cost of producing 1000 tons of 17 per cent R_2O_3 alum solution.

468 tons 66° Baumé sulphuric acid at $12.50	$5,850.00
265 gross tons bauxite at $9.90	2,623.50
Lubricating oil	20.00
Steam	100.00
Electric current 10,000 kilowatt hours (2 cents per kw. hr.)	200.00
Repairs to plant	500.00
Depreciation	600.00
Interest on investment	600.00
	$10,493.50

At the Columbus plant it is hardly fair to make any charge for labor because no additional labor is required to operate the new alum plant, consequently the labor item has been omitted in the above estimate.

When lump alum was being used here it was necessary to unload it from the cars, sack and weigh it, store it in the storage house, elevate it to the third floor of the head house, stack it up there and finally dissolve it in solution tanks as needed. In addition to all this handling there were three times as much material to move and three times as much storage space required, because, as has already been explained, 1 ton of bauxite will make 3 tons of alum. No additional help has been employed since this plant has been installed.

DISCUSSION

Mr. J. M. Diven: How about other chemicals, iron, or possibly arsenic, in the product?

Mr. Charles P. Hoover: Three grades of ore are mined, first, that used in the manufacture of metallic aluminum; second, that used in the manufacture of alundum, and third, that used in the manufacture of aluminum salts. At the present time only ore containing less than 2 per cent of ferric oxide (Fe_2O_3) is used in making aluminum sulphate. The speaker believes, however, that it is not necessary to demand bauxite of highest purity for making aluminum sulphate to be used for water purification purposes. It seems entirely possible that much of the cheaper grade bauxite could be used to ad-

vantage in making alum for water purification purposes. Low grade, cheap sulphuric acid contains rather a high percentage of arsenic, and when such acid is used in the manufacture of sulphate of alumina the product will of course contain arsenic. In order to get arsenic free acid it is necessary to specify contact process acid. Professor Bartow, of the Illinois State Water Survey, read a paper at the New Orleans meeting of the American Chemical Society on the presence of arsenic in filter alum, and in this paper it was stated that the quantity of arsenic present in commercial alum was so small that even if water were treated with 6 grains per gallon of highest arsenic content alum which could be found on the market it would be necessary to drink 5000 gallons of such treated water to get a medicinal dose.

Prof. J. M. Caird: What is the price of sulphuric acid?

Mr. Charles P. Hoover: At the present time we are paying $12 per ton for sulphuric acid of 66° acid. We have a contract for a year at that price.

Mr. A. W. Hawkes: The market price of sulphuric acid at the present time as compared with the price ruling at the time Mr. Hoover made his contract for sulphuric acid has practically doubled, due to the heavy demand brought about by war conditions. It might be very difficult for a water company that has not previously purchased sulphuric acid to secure any at this time at a usable price. Pyrites ore, which comes in material quantities from Spain, is used largely in this country in the production of sulphuric acid and the ocean freights have more than doubled since the outbreak of the war.

Mr. Charles P. Hoover: Filter alum, made by the old process, or made and used by the process just described, is made from sulphuric acid, and therefore, it naturally follows that if the price of sulphuric acid increases the selling price of alum will be increased. Even though the cost of acid does increase or double there still remains the same saving in the production of alum by this process over the production by the old process.

A Member: Has the halloysite making of alum not proved successful?

Mr. Charles P. Hoover: Attempts to make alum from halloysite, so far as the speaker knows, have proved unsuccessful. A plant for making alum from halloysite was recently built at Urbana, Ohio, but it was only operated for a few months and has now been dismantled. It was found to be practically impossible to filter silica from the crude halloysite syrup. At the Columbus water softening and purification works, where the crude syrup is being used without filtering, concentrating or crystallizing, halloysite is being used successfully.

A Member: You say that the bauxite was mixed in the tank which you illustrated. Do you boil it with a steam coil?

lead-lined

Mr. Charles P. Hoover: Briefly the process is as follows: 2 feet of water is first run into ~~the boiling~~ tanks, which are 8 feet in diameter, then the proper quantity of sulphuric acid is introduced. The reaction between the acid and water is so violent as to cause the solution to boil. Bauxite is then dribbled into the boiling acid solution at the rate of about 30 pounds per minute. The reaction between the hot acid solution and the bauxite is violent and the boiling continues as long as the bauxite is being introduced, this usually takes about two hours' time. Live steam is then used to continue the boiling process to complete the reaction between the alumina, of the bauxite, and the sulphuric acid.

Prof. James M. Caird: How much of that available alumina is consumed by the sludge? How much of it is lost in the sludge? Did you not say about 40 per cent?

Mr. Charles P. Hoover: No; about 6 or 7 per cent of the available alumina is lost.

Mr. Philip Burgess: What has been the attitude of the filter alum manufacturers in regard to this process? Have they intimated that in view of the experience at Columbus it might be practical and desirable for them, instead of furnishing the pure crystallized chemical, to contemplate a supply of the materials in the liquid form?

Mr. Charles P. Hoover: Will Mr. Hawkes, of the General Chemical Company, kindly answer the question which has just been asked by Mr. Burgess?

Mr. A. W. Hawkes: It would not be feasible or practicable for an alum manufacturer to attempt to transport alum solution for the reason that this solution has an acid reaction and attacks most metals, hence it would require a very expensive vessel in which to ship it. Then, too, there would be the question of paying freight from point of shipment to destination on the water in the alum solution.

From the speaker's past experience, he does not believe the manufacturers of alum will make any material advance in the price of sulphate of alumina to their regular customers, no matter where the price of sulphuric acid goes, as it has always been the policy of the manufacturers in the past to take care of their American trade, and contracts are being renewed now from day to day, regardless of the price of sulphuric acid, on the same price basis as ruled before the war. Generally speaking, it is believed the policy of the American alum manufacturer will be to take care of its regular customers in this country on practically the same basis they have been taken care of in the past.

THE EFFECT OF ALGAE ON BICARBONATES IN SHALLOW RESERVOIRS

By S. T. Powell[1]

The microscopical examinations of public water supplies have become universal, and in many places constitute routine laboratory tests, but these determinations are made principally for the purpose of the treatment of the supplies for the removal of algae and similar micro-organisms causing tastes and odors in the water. Water works superintendents and chemists in charge of such works have given but little study to the biochemical reactions of such plant life when present in reservoirs, and with the exception of various limological investigations that have been made, little data of this character are available. It is a well known fact, however, that these organisms do have a great effect upon the physical, chemical and biological quality of stored water.

In a recent investigation undertaken to determine the effect of dissolved gases in stored water upon ozonization of the supply of the Baltimore County Water and Electric Company, it was clearly demonstrated that certain forms of algae can within a comparatively short time entirely remove the free carbon dioxide from the water, as well as use up a considerable amount of the half bound carbon dioxide, thereby reducing the bicarbonate of calcium and magnesium to normal carbonates of these salts; at the same time causing the dissolved oxygen content of the supply to rise to a point of excessive supersaturation. Such conditions have been noted by many investigators, but these phenomena are not usually to be found in shallow reservoirs where the storage period of the water is relatively short and where the supply of free CO_2 in the raw water is considerable, due to high organic contents.

The two reservoirs used for storage purposes on the Herring Run system of this company are operated continuously, and have a combined storage capacity sufficient for twenty-one days' supply.

[1] Chemist and Bacteriologist of the Baltimore County Water and Electric Company.

The lower reservoir, which was put in use about twenty years ago, is an excavated earthen basin around which a bank was placed. When first put into service the top soil was not stripped but later the greater portion of it was removed to a depth of 12 inches. About four years ago on the bank of the lower side of this reservoir was placed a concrete slab so as to prevent high turbidities in the water on account of washing of the slopes during storms. Due to the organic nature of the contents of the water, there is an abundant food supply for heavy growths of algae, and for this reason it has been necessary to treat the water with copper sulphate many times each summer to keep down the growths.

The second reservoir was built only four years ago and like the first one is an earthen reservoir, but the top soil from this basin was practically entirely removed before it was put into service. This reservoir acts as a preliminary settling basin for the water before it flows to the lower one, the water passing directly from the effluent chamber of this reservoir to the lower one and from there to the ozonization plant.

The raw water feeding these reservoirs is supplied by Herring Run, a small surface water stream subject to some extent to surface pollution of the drainage area, and therefore is usually high in organic matter in suspension and in solution. Algae growths in this stream are as a rule not high but most of the growths develop after the water enters the reservoirs. The raw water receives some aeration just previous to entering the first reservoir, so that the dissolved oxygen is usually about 100 per cent of saturation and the free CO_2 content varies between two and ten parts per million.

In the investigation that was made during the summer of 1914, samples of water were taken regularly as the water flowed into the upper reservoir, again as it flowed into the lower basin, as well as of the effluent from this reservoir and at the pumping station. In all these samples determinations were made of the dissolved oxygen content, free CO_2, bicarbonate and carbonate alkalinity, as well as microscopical examination of the samples, enumerating the organisms present.

Compilation of these analytical data showed that the water during the passage through the upper reservoir increased in temperature 2.5° F., while the dissolved oxygen increased from 90 to 99.5 in percentage of saturation. The free carbon dioxide was reduced in all samples and in some of the samples completely exhausted, and

in the samples in which the free CO_2 was all used up the bicarbonates were reduced, on an average, from 52 to 43 parts per million. At the same time it was noted that the average increase in the algae count was from 52 to 260 organisms per cubic centimeter, or an increase of 400 per cent.

In the lower reservoir the average temperature increase over the water in the upper reservoir was 2.5° F.; the dissolved oxygen increased 25.5 in percentage of saturation, while with one exception the free CO_2 was entirely exhausted, and the bicarbonates were reduced 11 parts per million. The algae count in this reservoir increased 8 per cent over the average count in the upper reservoir water, 444.2 per cent increase over the raw water count.

Diagram I shows that as the algae increased there was a proportional increase in the percentage of saturation of dissolved oxygen, although the temperature of the water was greatly increased at the same time.

As is seen in Diagram II, the free CO_2 was exhausted from the water as the micro-organisms increased and the half bound CO_2 from the bicarbonate was drawn upon to furnish the necessary food supply to support the growth. This chart is interesting as it also shows that exhaustion of the free CO_2 that took place during passage through the reservoir was readily replaced after passing through the aspirators of the ozone plant.

Diagram III shows the number of organisms of each species in relation to the total count.

No tests were made in this investigation to compare the bacterial count in the supply with the multiplication of algae, but in tests made in the laboratory it was found that as the algae increased there was a general tendency of reduction in the number of bacteria in the sample (Di gram IV); also after the algae had been killed by treating the sample with copper sulphate there was a very great increase in the number of bacteria. To what extent the increase in bacteria was due to an increased food supply caused by killing the algae growth, or the other chemical changes in the supply, is difficult to determine, but it is interesting to note, however, that these forms of vegetation can and do cause great chemical and bacteriological changes in a water in which they thrive.

It is not known if all the microscopical forms of life that are found in waters are capable of bringing about these biochemical changes in a water as have been noted in these tests, but the organisms com-

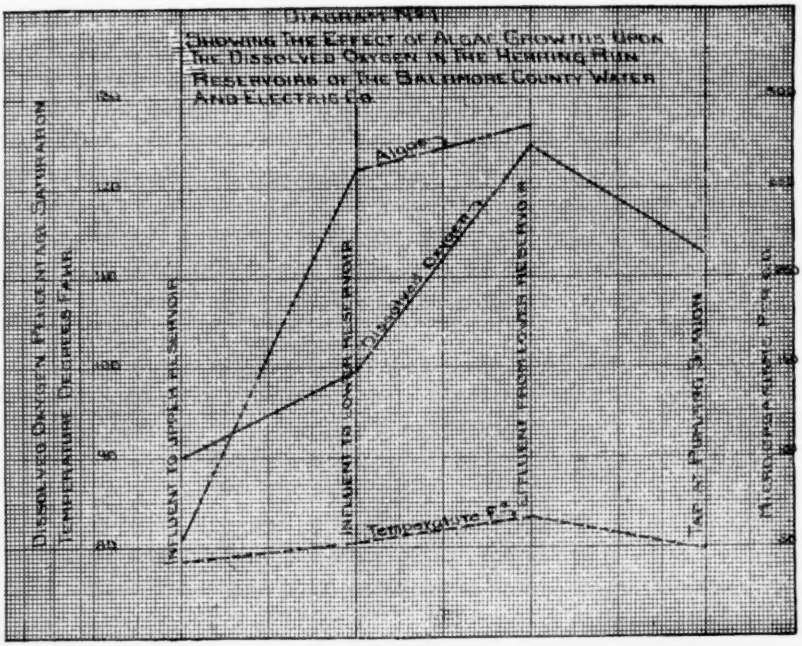


Diagram No 1
Showing The Effect of Algae Growths Upon The Dissolved Oxygen in The Herring Run Reservoirs of The Baltimore County Water And Electric Co.
Dissolved Oxygen Percentage Saturation
Temperature Degrees Fahr.
Micro-organisms Per c.c.
Algae
Dissolved Oxygen
Temperature F°
Influent to Upper Reservoir
Influent to Lower Reservoir
Effluent from Lower Reservoir
Tap at Pumping Station

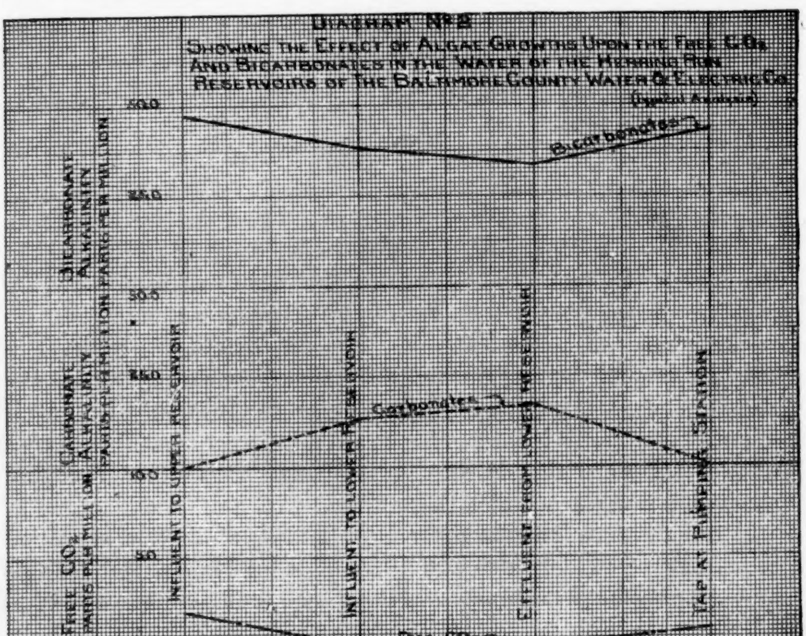


Diagram No 2
Showing the Effect of Algae Growths Upon the Free CO_2 And Bicarbonates in the Water of the Herring Run Reservoirs of The Baltimore County Water & Electric Co.
(Typical Analysis)
Bicarbonate Alkalinity Parts per Million
Carbonate Alkalinity Parts per Million
Free CO_2 Parts per Million
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Bicarbonates
Carbonates
Free CO_2
Influent to Upper Reservoir
Influent to Lower Reservoir
Effluent from Lower Reservoir
Tap at Pumping Station

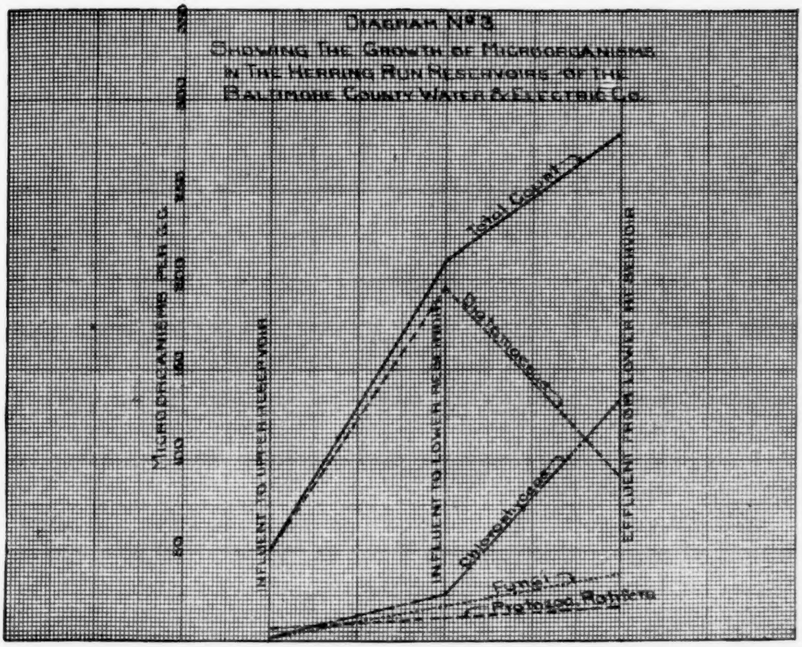


DIAGRAM No. 3
SHOWING THE GROWTH OF MICROORGANISMS
IN THE HERRING RUN RESERVOIRS OF THE
BALTIMORE COUNTY WATER & ELECTRIC CO.
MICROORGANISMS PER C.C.
INFLUENT TO UPPER RESERVOIR
INFLUENT TO LOWER RESERVOIR
EFFLUENT FROM LOWER RESERVOIR
Total Count
Diatomaceae
Chlorophyceae
Fungi
Protozoa, Rotifers

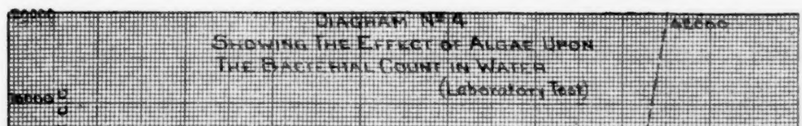


DIAGRAM No. 4
SHOWING THE EFFECT OF ALGAE UPON
THE BACTERIAL COUNT IN WATER
(Laboratory Test)
BACTERIA PER C.C.
ALGAE PER C.C.
Growth Killed With
Copper Sulphate
DAYS
2
3
4
5
6
8
9

prising the true algae are no doubt more active in this respect. During the process of photosynthesis these organisms store up energy by absorbing carbon dioxide from the water and when this is exhausted draw upon the half bound CO_2 in the form of bicarbonates, giving off oxygen at the same time. It is because of this action that oxygen is formed in the water faster than it can be diffused, causing a condition of supersaturation, as has been noted in these tests.

CONCLUSION

It is seen from the above mentioned tests that certain forms of microscopic life in water can cause rapid changes in the chemical composition of the supply by exhausting the free carbon dioxide and reducing the bicarbonate alkalinity to normal carbonate alkalinity, and at the same time cause the water to become greatly supersaturated with oxygen.

It is quite essential that the growth of algae and allied organisms should be prevented in reservoir water, as the neglect of such conditions may cause serious troubles, not only from complaints due to tastes and odors, but on account of filter troubles so often caused by these organisms. Not only are conditions of this kind prevalent but active growths may so alter the chemical composition of the water as to call for radical changes in the methods of operation of the purification systems.

THE TRUE OBJECT OF WATER ANALYSIS

By Frank L. Rector, B.S., M.D.

The question of water analysis has been discussed from many angles, by many competent analysts. No uniform agreement has been reached, and doubtless will not be reached as long as waters of variable composition and source are examined.

It has been demonstrated repeatedly that no hard and fast rules can be promulgated for application to all classes of waters. The nearest attempt to this is the standard of impurity established by the United States Public Health Service for drinking water on interstate passenger carriers. To the writer it seems that the relation of the 37° C. count to the permissible gas production is not well balanced. This standard could not be met by many municipalities having what is ordinarily termed a safe supply. Problems entering into the consideration of a municipal supply are so many and varied that one standard for all is out of the question, unless unnecessary requirements are demanded of some.

Waters of surface origin and surface storage will show a different bacterial flora than those of underground source. In surface waters the 37° C. count doubtless suffices for most purposes. But in underground waters from safe sources the 20° C. count gives us much valuable information. In this latter class water organisms growing at 37° C. are, or should be, practically absent, and the 20° C. bacteria are the ones most commonly found.

The 37° C. organisms are looked upon with more distrust than are the 20° C. types; but each group tells its own story of past performances of a water and should be considered. We do not know that all 37° organisms are harmful, in fact we know they are not all harmful; neither do we know that all 20° C. organisms are harmless. Do we know definitely that among the large numbers of bacteria at 20° C. found at times in a water, there are none capable of setting up pathological conditions when taken into the system? Their presence in large numbers tends, at least, to show laxity in the care of that particular water.

As an illustration of the value of the 20° C. count the following results of analysis of filters may be cited. During the past year the writer made a study of the efficiency of filters as installed in homes and offices in Brooklyn. The 550 samples tested were about equally divided between raw and filtered water. The raw water gave a fairly low bacterial count, the average of some 60 analyses giving 28 bacteria at 37° C., and 217 at 20° C. The filter effluents frequently gave low counts at 37° C. but very high counts at 20° C. Had the 37° C. count only been considered, these appliances would have rated as efficient, when as a matter of fact, they were very inefficient, as regards bacterial removal. The following table from the results of the investigation illustrates this point:

RAW WATER		FILTERED WATER	
37°	20°	37°	20°
25	200	0	600
20	100	0	123
11	80	3	325
0	25	0	100
40	100	0	154
11	80	2	79
66	800	21	1,465
443	2400	220	25,000
12	390	7	420
3	80	1	150
6	35	1	230
6	75	0	125
8	50	1	100
27	1600	8	2,500
9	70	0	155

The samples noted above were plated within one hour after collection, and some in much less time, so there was no chance for multiplication between collection and plating.

Each source of water supply should be considered individually, and while general conclusions may be drawn, they must be applied with caution. Analysts should determine what elements in a given water supply, either chemical, bacteriological or microscopical, are subject to the widest variation, and after these facts are established, should devote their routine examination more closely to these vari-

ables. This will show more readily when changes occur and remedies can be applied more quickly.

The above suggestion necessitates frequent and regular examinations of water supplies, a thing which all will agree is highly important. A monthly or quarterly analysis is not sufficient no matter how safe a water is presumably. Analyses should be made weekly, or better daily. The more purification a water undergoes, the more frequently should it be analyzed in order to control the purification.

First hand knowledge regarding a water supply is of the greatest importance. A sanitary survey of the watershed takes equal place with laboratory analysis. The days of "absent treatment" in determining the sanitary condition of a water supply by analyzing a sample submitted with no knowledge of its previous history, are happily past.

In conclusion the writer would emphasize the necessity of a careful study of all influences bearing upon a given water, and a judicious use of that information, rather than judge all waters by a strict laboratory standard.

SOME CONSIDERATIONS IN ESTIMATING THE SANITARY QUALITY OF WATER SUPPLIES

By W. H. Frost[1]

The subject indicated by the title of this paper is obviously too broad to be comprehensively discussed within a brief space. The present discussion will, therefore, be limited, first of all to a consideration of water supplies with reference solely to the causation of typhoid fever, which is the typical, and in this country the most common and serious water-borne infectious disease. The scope may still further be limited to a discussion of the general nature of the evidence upon which an opinion as to the sanitary quality of a water supply must be based.

A scientific basis for estimating the sanitary quality of a water supply with reference to its effect in the causation of typhoid fever can be established only by coördinating the results of two distinct lines of study. The first has to do with the nature and extent of the pollution of the water; the second with the extent of the effect produced by a given amount of pollution in the causation of typhoid fever.

The point which it is desired to especially emphasize is that knowledge of the pollution of a water supply has no significance except as it is coördinated with a knowledge of the effect which the known degree of pollution will produce. However precisely we may be able to determine the nature and extent of pollution, the accuracy of an estimate of the sanitary quality of water must always be limited by the precision with which its effects can be determined or estimated.

DETERMINATION OF THE EXTENT OF POLLUTION

The nature and extent of the pollution of a water supply is determined by studies from two angles, namely: first, by a survey of the sources of pollution, and of the safeguards which stand between

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these sources and the ultimate consumer of the water; second, by laboratory examinations designed to determine the actual amount and kind of pollution present.

SANITARY SURVEY

Since typhoid fever is caused solely by the typhoid bacillus, a sanitary survey of the sources of pollution of a water supply should have reference primarily to the sources of pollution with typhoid bacilli. These organisms, so far as known, breed only in the bodies of infected persons, whence they are discharged in the feces and urine. The term "infected persons" comprises not only all persons known to be ill with typhoid fever, but also a considerable proportion of recent convalescents, and a small proportion, probably about 2 per cent, of all persons who have previously had typhoid fever; perhaps also a small proportion of persons who have never shown recognizable symptoms of infection. By a careful survey it is possible to enumerate all the visible sources of typhoid infection, that is all the known cases of typhoid fever from which a given water supply may become polluted. The concealed sources, that is convalescents and "carriers," cannot be individually located; but their probable numbers in a well studied population can be estimated with reasonable accuracy.

It may be considered that all water, whether taken from surface or underground sources, has at some time since its precipitation been in contact with the surface of the earth, and has consequently been more or less exposed to pollution with the intestinal discharges of all persons and lower animals upon its catchment area. Between the sources of pollution and the ultimate destination of the water are numerous agencies operating to reduce the numbers of typhoid bacilli and other intestinal bacteria which may reach the consumer. These safeguards comprise all the agencies which tend to destroy typhoid bacilli and other intestinal bacteria in the natural and artificial processes of sewage disposal and water purification. In order, then, to arrive at an estimate of the numbers of typhoid bacilli which will reach the consumers of a water supply from known sources of pollution, it would be necessary to calculate accurately the extent of the action of all these agencies which tend to diminish pollution. The problem is so complex as to be impossible of solution without the aid of further means of observation.

BACTERIOLOGICAL EXAMINATIONS

Of the laboratory examinations applicable to determining the nature and extent of pollution of a water supply bacteriological examinations have the most direct bearing upon sanitary quality, which is a question of bacterial pollution. The most specific of the bacteriological examinations in general use are quantitative tests for bacteria of the B. coli group, since these tests afford a direct measure of the numbers of intestinal bacteria present, and since typhoid bacilli are found only in association with intestinal discharges. Nevertheless, such tests, however accurate and specific they may be, show only the extent of pollution with intestinal discharges in general; they do not distinguish between pollution with intestinal discharges from lower animals which are not subject to infection with typhoid bacilli, and the much more dangerous pollution from human sources. They still further fail to distinguish between human discharges actually containing typhoid bacilli and discharges free from this specific infection.

CORRELATION OF SANITARY SURVEY AND BACTERIOLOGICAL EXAMINATIONS

The significance of bacteriological examinations may be greatly increased by correlation with a careful sanitary survey, which gives information as to the probable sources of such intestinal bacteria as may be present. It is conceivably possible, by combining a careful sanitary survey with bacteriological examinations, to estimate roughly the probable numbers of typhoid bacilli present in a given water supply. The data necessary for such an estimate are:

1. A knowledge of the numbers of intestinal bacteria present in the water.
2. Such knowledge of the sources of pollution as to enable an estimate of the proportion which intestinal bacteria from human sources are of all intestinal bacteria present.
3. An estimate of the ratio of typhoid bacilli to all bacteria of the B. coli group in the discharges of the human population which contributes to the pollution of the given water supply.

A more or less accurate estimate of the probable numbers of typhoid bacilli present in a water supply represents the maximum of information which we may hope to obtain regarding the nature and

extent of the significant pollution. Even this complete knowledge, however, would fail to give an accurate measure of the sanitary quality of the water, unless it could be correlated with a knowledge of the effect which the known numbers of typhoid bacilli will produce in the causation of typhoid fever among persons who drink the water.

To recapitulate; sanitary surveys and bacteriological examinations give only indirect and inferential knowledge as to the probable presence and numbers of typhoid bacilli in a water supply. Even were this knowledge much more direct and exact, it would still fall short of being all that is needed for an estimate of the sanitary quality of the water. The second requisite is an equally exact knowledge of the effects which the known pollution will produce.

DETERMINATION OF THE EFFECTS PRODUCED BY WATER SUPPLIES IN THE CAUSATION OF TYPHOID FEVER

The exact dosage of typhoid bacilli necessary to cause infection is unknown, primarily because it has not been possible to determine directly the numbers of bacilli actually ingested by individuals who have contracted typhoid fever. Determination of the effects of a given dosage of typhoid bacilli even by indirect means is exceedingly difficult because of the probable influence of several variable factors other than dosage in causing infection.

Infection signifies more than the mere introduction into the human body of a given number of living specific organisms; it signifies the establishment of these micro-organisms within the body, their multiplication, invasion of the body tissues and the formation of toxic products, all of which must be accomplished against the resistance of the human body. The introduction of typhoid bacilli into the human digestive tract inaugurates a struggle between the infecting organisms on one side and the human body on the other. Infection results only when the typhoid bacilli have overcome the resistance of the body in the preliminary stages of this struggle, and have reached a stage of development within the body such as to call forth a final effort against them, exhibited in a general reaction which we recognize as the symptoms of typhoid fever.

The following are some of the theoretical considerations which may influence the outcome of the struggle and determine whether

or not infection will result from the introduction of living typhoid bacilli into the human body. On the part of the bacillus there is the factor of "infectivity," or ability to establish itself and multiply within the body. There is also the factor of "pathogenicity" or "virulence," that is ability, after having become established in the body, to give rise to toxic products which will result in illness. It is at least probable that typhoid bacilli may vary widely and perhaps independently in these two respects. On the part of the human body a variable factor is the ability to resist infection, or its antithesis "susceptibility." There is good reason to believe that susceptibility to typhoid infection varies widely in different individuals, and perhaps in the same individual at different times. Except for the fact that resistance is greatly increased by prophylactic vaccination and by a prior attack of typhoid fever, little is known of the circumstances which affect susceptibility; and there are no means of directly measuring the resistance or susceptibility of an individual to this infection.

Other things being equal, we may well suppose that dosage, that is, the number of typhoid bacilli introduced, is the factor which determines whether or not infection will result. It is highly probable that the resistance of the human body against typhoid infection is relative, not absolute; that an individual capable of resisting the invasion of a given number of typhoid bacilli would not be able to resist invasion of say ten times that number. Or, to state it differently, the more numerous the typhoid bacilli introduced, the greater is the probability that some of them will succeed in passing the defenses of the body. In comparing individuals, however, we cannot assume that dosage is the determining factor in infection because of the possible influence of the variable unknown factor of individual susceptibility. If, however, we divide a population into sufficiently large groups, similar in respect to age-distribution and other general characteristics, we may assume that the average of susceptibility is the same in all groups. Given, then, a uniform infective agent, that is typhoid bacilli derived from the same source, we may assume that dosage now becomes the determining factor; and that the occurrence of typhoid fever in any group will be proportionate to the exposure of that group to infection.

Reversing the argument, it may be concluded that the dosage or exposure to infection has been greatest in that group exhibiting the highest proportion of cases. This principle of reasoning is commonly

applied in undertaking to locate the source of typhoid infection. The reasoning is valid only when the population groups are sufficiently large and the number of cases occurring in each sufficient to be significant.

This review of the factors entering into infection is intended to illustrate the difficulties in the way of determining the effects of a given dosage of typhoid bacilli. Even were it possible to undertake human experiments, it is obvious that these would have to be performed on a most extensive scale, with large groups of people and with bacilli derived from many sources, subjected to many conditions. Especially would it be difficult, by such experiments, to arrive at a definite conclusion regarding the minimum dosage of typhoid bacilli which might occasionally result in infection. As a matter of fact, lacking experimental observations, we have only indirect means of determining the probable dosage of typhoid bacilli necessary for infection.

SOURCES OF KNOWLEDGE CONCERNING THE EFFECTS OF WATER SUPPLIES IN CAUSING TYPHOID FEVER

A knowledge of the actual effects of water supplies in the causation of typhoid fever is derived from studies of epidemic outbreaks and endemic prevalence. The endemic typhoid occurring in any community includes the sum total of cases resulting from the operation of all causes. While communities differ markedly in respect to their rates of endemic typhoid prevalence no community of considerable size in this country is altogether free from the disease. An epidemic, in the commonly accepted sense, can not be precisely defined, since the term is a relative one. Any outbreak of cases sufficiently numerous and sudden to stand out distinctly separated from the usual endemic typhoid in that community may be considered an epidemic. The proportion of cases to total population which may be considered to constitute an epidemic depends, then, to some extent, upon the usual rate of typhoid prevalence in the community.

A sharply defined epidemic of typhoid fever affords the best opportunity to determine definitely the effect of a water supply in the causation of this infection. This is so primarily because the very distinctness and sudden development of an epidemic argue the operation of a single, distinct and unusual cause, the spread of infection

from a single source, since it is essentially improbable that two or more unusual sources of infection should have developed independently and simultaneously.

Space does not permit more than the briefest discussion of the methods whereby a water supply may be proven to have caused an epidemic of typhoid fever. Starting with a general knowledge of the sources and potential routes of typhoid infection, and with the assumption that the epidemic has had its origin from a single source, it remains to find the source and vehicle of infection common to all or most of the cases. This is accomplished by investigation of each case, inquiring into all the routes by which infection might have reached this case, that is into the circumstances of any exposure to infection from a recognized prior case of typhoid, and into the sources of all articles of food and drink. Comparing the histories of a sufficient number of cases it is easy to arrive, by elimination, at the vehicle of potential infection common to all, or nearly all. In the case of a water supply used by a large majority of the population the mere fact that all the typhoid patients have drunk this water is obviously of no special significance, since this would necessarily be so, no matter what the cause of the epidemic.

It is, in such case, necessary to *exclude other vehicles of infection*, to show that the water supply is the *only* vehicle of infection common to a significant proportion of the cases. The next step in the evidence is to demonstrate the probability that the water supply was infected with typhoid bacilli at such a time as to account for the epidemic. This can usually be accomplished, even though it may not be possible to find the individual sources from which the water supply became infected. Finally, if it is true that the water supply has been the means of disseminating the epidemic, all the circumstances of the outbreak will be more fully consistent with this than with any other hypothesis, forming a conclusive chain of circumstantial evidence.

A great number of well studied typhoid epidemics, conclusively traced to infection of water supplies, have afforded opportunities to observe and measure definitely the extent of infections caused by these water supplies among their consumers. Unfortunately, the water supplies responsible for such definite epidemics have seldom been closely examined bacteriologically during the period of their known infectivity, so that the extent of pollution which has produced the definitely determined effect is not known. The study of

epidemics has, therefore, failed to give a definite idea of the probable dosage of typhoid bacilli responsible for the causation of known percentages of infection among those exposed.

The effect of water supplies in the causation of endemic typhoid fever is a matter of greater public health importance and at the same time more difficult to determine, because the endemic typhoid in a community represents the sum total of infections from all sources and through all routes. Our most definite knowledge and nearest measure of the effects of known water supplies in contributing to the endemic prevalence of typhoid fever is derived from the study of communities in which a distinctly marked change in the extent of pollution of the water supply has been followed by a correspondingly definite change in the rate of typhoid prevalence. Among the best examples are the many cities in which effective filtration of polluted surface water supplies, previously used without purification, has been followed by a marked decrease in typhoid prevalence. Even here, however, the observed reduction in typhoid prevalence is not an altogether reliable measure of the previous effect of the polluted water supply in the causation of this disease. It is possible, on the one hand, that a reduction in the amount of water-borne typhoid, eliminating a number of local sources of infection, may have resulted in a reduction of cases previously caused by secondary infection from these sources, thus magnifying the apparent effect of the water supply. On the other hand, it may be that the water-borne typhoid, though obviously reduced, has not been completely eliminated. The effect of this would be to reduce the apparent previous effect of the water supply.

A study of such communities as above cited, during the period when known polluted water was used, has revealed certain fairly distinctive characteristics in the distribution of typhoid fever in communities where a large proportion of the total endemic typhoid is water-borne. Briefly these characteristics are:

1. A rate of prevalence notably higher than in other communities, similar in respect to climate and other significant conditions, but using water supplies less highly polluted.

2. A prevalence relatively high during the winter and spring, often reaching its maximum in these months.

3. A relatively uniform distribution throughout the population, without reference to environmental factors other than water supply.

In these same communities, subsequent to purification of their

water supplies, and in other communities where intensive studies have shown that the water supplies are small or negligible factors in the causation of the disease, endemic typhoid shows contrasting characteristics in its distribution, viz:

1. A rate of prevalence generally proportionate to the opportunities afforded for contamination of food supplies with human excrement. Conspicuous factors are faulty methods of local sewage disposal, resulting in the exposure of human discharges to flies and other carriers; and laxity of sanitary administration in respect to isolation of typhoid patients and the safeguarding of milk and other food supplies.

2. A seasonal prevalence quite regularly reaching its maximum during the summer and autumn months, declining markedly during the winter and spring.

3. A relatively high prevalence among those elements of the population who, by reason of their habits or environment, are evidently more exposed to infection from local sources.

These and other more or less distinctive characteristics in the distribution of typhoid fever assist materially in arriving at an estimate of the probable effect of the public water supply in contributing to the endemic prevalence of the disease in a given community. The accuracy of such an estimate is proportionate to the thoroughness and precision of the study upon which it is based. It may be emphasized, however, that the number and complexity of factors entering into the causation of endemic typhoid is such that we can not hope to estimate with quantitative precision the effect of water or any other single factor. An illustration will perhaps serve better than a general discussion to present a conception of the limitations of epidemiologic methods in determining the precise influence of a single factor.

Assume the hypothetical case of a city where a rather highly polluted surface water supply has been in general use, and where the average rate of typhoid incidence is 1000 cases per 100,000 of population yearly. Suppose that, in actual fact, 80 per cent of the total cases are due to infection conveyed by the water supply, the remaining 20 per cent being due to infection from all other sources. The distribution of typhoid in this community would, in all probability, be such as is characteristic of comunities in which a polluted surface water supply is the predominant vehicle of infection. By careful study, it should be readily possible to conclude that most of the

typhoid was water-borne, and a relatively small proportion due to infection from other sources. It would not, however, be possible to determine definitely the exact percentage due to water and to other factors respectively. Suppose now that following the installation of filters, providing a water supply showing only slight evidences of pollution, the total incidence of typhoid fever in this community has been reduced to one-fourth, that is 250 cases per 100,000 yearly. Assume that factors other than water cause precisely the same amount of typhoid as previously, that is, 200 cases per 100,000, and that the water supply continues to cause the remainder, or 50 cases per 100,000. The proportion between the water supply and other factors in the causation of the disease has now been reversed, so that the water supply causes only 20 per cent of the total cases. Careful study might now be expected to show conclusively that by far the greater proportion of the cases were due to infection contracted from sources other than water supply. It is, however, extremely doubtful that it would be possible to determine conclusively whether or not the water supply continued to cause a certain small, not definitely determined proportion of cases. In other words, the methods of study are not sufficiently accurate to differentiate between, say, 20 per cent of cases due to water-borne infection, 10 per cent, and none.

The principle which the above illustration is intended to illustrate is simple. A number of factors, more or less obscure, complex and interrelated, enter into the causation of endemic typhoid fever. The operations of individual factors can be distinguished only by circumstantial evidence. Quite evidently the ease and certainty with which the effect of water supply or any other individual factor can be recognized is proportionate to the prominence of the factor. The larger the ratio of its effect to the combined effect of all other factors, the more distinctly can it be discerned. Conversely, as the effect of any single factor becomes smaller in proportion to the total, the greater the difficulty of recognizing and distinguishing it; and there is entirely good reason to believe that the effect becomes indistinguishable before the factor is entirely eliminated. Applying this principle to the judgment of water supplies, the fact that it is impossible to clearly detect evidence of water-borne infection in a community does not satisfactorily prove that the water supply actually plays no part in the causation of this disease. It must then be recognized that we are as yet unable to determine the least amount

of pollution of a water supply which may be responsible for a very slight incidence of typhoid fever.

To recapitulate: bacteriological examinations, combined with a careful survey of the sources of pollution and of the safeguards against them, give accurate knowledge of the extent of pollution of a water supply in terms of intestinal bacteria from all sources. They give only indirect and inferential knowledge of specifically dangerous pollution with typhoid bacilli. To make the knowledge acquired by bacteriological examinations and sanitary surveys significant with respect to the sanitary quality of water, it is necessary to know the *effects* produced by a given amount of pollution. Such effects can be definitely ascertained and measured in the case of epidemic outbreaks, proven to be due to the use of polluted water supplies. The effects can be definitely recognized but not accurately measured in the case of highly polluted water supplies causing high rates of endemic typhoid prevalence. In the case of slightly polluted water supplies it is not philosophically possible to probe by present methods whether or not they may cause a relatively small incidence of typhoid fever, so small as to be obscured by other more prominent factors.

This paper is not intended to present a pessimistic point of view or to deny the possibility of forming a reasonably accurate estimate of the sanitary quality of a water supply. On the contrary, the writer wishes to express his entire confidence in the reliability of an expert opinion, formed after careful study from all angles, and stated conservatively, with an understanding of the limitations of the evidence. Unless these limitations are remembered, however, there is always the danger of drawing too sweeping conclusions from evidence bearing solely upon the extent of pollution of a water supply.

As regards establishing a firmer basis for opinions in the future, this must obviously be accomplished by improving and extending not only laboratory studies of the quality of water supplies, but equally epidemiologic studies of their relation to typhoid prevalence. Methods of epidemiologic study, like bacteriological and chemical methods must be so standardized that results can be summarized into a general fund of knowledge. Routine bacteriological examinations of water supplies, closely coördinated with careful, long-continued epidemiologic studies may be confidently expected to increase, perhaps to an extent not now foreseen, our ultimate knowledge of the sanitary safety of water supplies.

DISCUSSION.

Mr. Frederick H. Stover: Dr. Frost made the statement that improved water supplies in many cases got credit for doing more than they really did, in that, while they perhaps reduced the primal causes, and while many secondary contact cases which might have resulted from these did not occur, the water supply erroneously got credit for the whole. Was the statement understood correctly?

Dr. W. H. Frost: No; the statement was not quite in that form. The statement was that it was a possibility.

Mr. Frederick H. Stover: In that case why should not the water supply have the credit? The decrease in typhoid mentioned above is due to the improved supply, therefore why does not the supply have the credit for accomplishing it?

Dr. W. H. Frost: It does get the credit, but there is a possibility of an error.

Mr. William H. Jewell: The speaker was very much interested in Dr. Frost's paper, because there are a lot of mighty fine facts stated there—a lot of material to think about and work upon; but the thought was suggested that a matter concerning the vital statistics of typhoid fever in our municipalities was one that was correlated with the milk supply, and the question arose whether we ought not to consider the effects of the water that goes into the milk, either directly or indirectly, in relation to the typhoid statistics of our cities.

An instance occurred at the little village of Park Ridge, near Chicago, where they had twenty cases of typhoid fever, one right after another, in less than ten days, and the public schools had practically to close. Now that was traced by the health commissioner to a certain milk supply. After looking into the question a little bit, it was found that this dairyman was supplied with water from the owner's well. Now, he was within the corporate limits and the supply of the village water works was available. It would seem that it is not doing the water works manager or superintendent justice not to consider those cases, and if possible provide some means to make these dairies take city water when they are within the limits

of main extensions, and the speaker thinks that you will find that where the milk supply of a local community is derived largely from its environments, and water mains are extended out the typhoid becomes less, due to the general propaganda against impure well water.

Dr. Bartow was asked if he knew of any jurisdiction over the water supply of these dairies in the state; and it appears that, in Illinois, there is no investigation being made of the water supplies for dairies, but there should be.

Dr. Jesse M. Worthen: At Charleston, S. C., last spring we had a hundred and sixty cases of typhoid within three weeks, and it was traced to the milk supply from two dairies, one using cistern water and the other using their own well water. One was within the corporate limits; the other was not, both of them were within three hundred feet of the water supply. The health officer traced the epidemic to these two dairies absolutely; and when they were made to sterilize everything, there were no new cases.

Dr. Edward Bartow: Those who have read the report on standards for interstate carriers have noticed that no chemical standards have been formulated, and they will notice that in the work which we did in the examination of our one hundred samples, we made chemical examinations. Apparently the chemical content of the water was pretty good.

Mr. Charles P. Hoover: It does not seem advisable, to the speaker, to establish a standard of hardness for water to be used by interstate carriers, but it might be well to insist that water containing more than one grain per gallon excess lime or any excess soda ash should not be used. This would prevent water tanks from being filled with water from railroad water softening plants. The speaker knows from experience that the water at these plants is sometimes grossly overtreated with the softening reagents. Again if the standard demanded a water of low degree hardness it would be a further incentive to use water from these plants. Although we have not, as yet, had time to give the new bacterial standard a thorough test, still we feel that it may be too high.

The daily bacterial records at the Columbus plant indicate that positive presumptive tests in 10 cc. portions of the filtered supply

do not always mean an unsafe water, for they sometimes occur when 1 cc. portions of the same sample do not contain any bacteria. Therefore, the bacteriological standard for water adopted by the Treasury Department for the drinking water supplied to the public by common carriers in interstate commerce may work an injustice upon well regulated municipal water purification plants, for undue suspicion is apt to be thrown upon the plant, and the minds of the citizens may become unduly prejudiced against their public water supply if it becomes known that the water has at some time failed to meet the government requirements.

Mr. George R. Taylor: Will Professor Bartow please state whether in his opinion there would be any difference between the storage of a filtered water and the storage of an ordinary spring or raw water in the cooler. That is, will not the filtered water deteriorate more rapidly than water that has not been treated?

Dr. Edward Bartow: That would depend upon conditions. With the same kind of bacteria in each sample, the deterioration, which would be measured in the growth of bacteria, would probably be the same. With different bacteria to start with, measuring simply the number of bacteria, there would probably be a difference; but which would deteriorate the more rapidly the speaker would not pretend to say.

Dr. Jesse M. Worthen: Is the question of whether the ice used in the tanks on the common carriers is artificial or natural ever considered in the quality of the water after it has been iced?

Dr. Edward Bartow: Many of the common carriers, especially on the Pullman trains, do not allow the ice to come in contact with the water. In the coaches it is not quite so true. Natural ice is, as a rule, good when taken. It may be, of course, contaminated in handling. That is something that must be looked out for, and the railroads are coöperating to eliminate, as far as possible, any contamination after the water is collected.

Dr. Jesse M. Worthen: How about the manufactured ice? You very often strike it containing sodium chloride from leaky pans, and sometimes that comes in contact with the water and establishes a

chemical standard of different elements that would increase the chlorine and ammonia if it came in contact with the water.

Dr. Edward Bartow: In the samples of water which we analyzed we found some with very little chlorine and a residue of from thirty to fifty parts per million. That would mean that the water which we obtained from the coolers was practically melted ice. It would be possible for a railroad in a country where the residue is high, a complaint that is often made through the southwestern states, to so dilute the water with ice water as to have a pure soft water that will conform to any standard; thus would be avoided any of the physiological actions on the passengers that would be caused by a change from a comparatively soft water to a water with a high residue consisting perhaps of sodium sulphate and magnesium sulphate. In the one hundred waters that we analyzed there were only three that had a residue of over five hundred.

Mr. Frederick H. Stover: It would seem that where there is only a bacteriological standard, it might be possible for carriers to get around that easily, simply by filling a supply tank from any convenient source, chlorinating this tank and then filling the containers in the cars from this. In this way it would be comparatively easy to take water from almost any convenient source and yet have it pass inspection when drawn from the coolers in the cars.

While it might be possible to obtain a fairly safe water in this way, and one that would pass the bacteriological test in many cases, the continued use of such a water would be apt to prove undesirable, since the supervision of such a small installation would in a majority of cases be inferior to that of a larger municipal supply.

A chemical standard if adopted should be along broad lines and susceptible of a liberal interpretation.

Mr. Wilson F. Monfort: Will Mr. Hoover explain one matter in his discussion, when he spoke of gas formation; does he refer just to the formation of gas in lactous broth?

Mr. Charles P. Hoover: Gas formation in both lactose bile and dextrose broth. In some of the tabulated literature on bacterial work it has been noted, on several occasions, that more B.

coli were found than total numbers of bacteria. If these results are correct then it would appear that too much dependence cannot be placed on results obtained with liquid media.

Dr. W. H. Frost: The speaker has no special license to act as spokesman for the public health service, but he may, perhaps, be able to present a point of view from the side of the service. The public health service has not only the authority but the responsibility of protecting the health of passengers in interstate traffic. There are two ways in which the question of controlling the water supplies on common carriers may be approached. First, by instituting an inspection of all the sources of water supply and by maintaining careful supervision over them and over methods of handling, such as to insure that safe water will be served to passengers. This is, perhaps, the ideal way, but a little consideration will show that this method necessitates not only an extensive survey to cover all the sources of supply, but the maintenance of a large force to keep up supervision over these sources and the maintenance of another large force to supervise methods of handling the supplies.

The other angle from which the proposition might be approached is by applying the same principle as is applied in the enforcement of pure food laws; that is, by requiring that the water, as served to passengers, shall conform to certain specified standards of quality, placing upon the carriers the responsibility of choosing such sources of supply and methods of handling as will enable them to meet the requirements. This automatically imposes upon the carriers the necessity of using only good sources of supply and cleanly methods of handling.

The standards adopted by the Treasury Department are quite properly rigid and high, because of the fact which the speaker tried to bring out this morning, that it is difficult to say just where the danger line lies. It seems the only safe policy is to adopt such standards as will certainly insure safe water. Undoubtedly the regulations are rigid; but it is intended that they should be. Common carriers use only comparatively small amounts of drinking water, and, although it may involve using purification processes which would be quite expensive if applied on a large scale to municipal supplies, it is entirely practicable for carriers to purify their water supplies to the point where they meet the requirements.

The speaker does not know exactly what steps the public health

service is taking or proposes to take in enforcing these requirements, or just how it is intended to apply the standards; but does know that the service does not wish to embarrass those of you who have charge of municipal supplies by wholesale condemnation of all water supplies which do not conform to these standards. If the application of these standards will help to encourage municipalities to improve their water supplies, that will be a good thing.

While speaking, in reference to a statement which Mr. Hoover made, that B. coli, according to standard methods of testing sometimes turn out ten times as numerous as the total bacteria, the speaker would say that he has never had any such experience; our results are very consistent. Of course it might easily happen that in a single examination or a small series the B. coli would figure out more numerous than total bacteria, but the speaker never found it so in the results of any considerable series.

Mr. Philip Burgess: Would not the embarrassment be rather upon the common carrier than upon the community? In an instance where a local Pullman sleeper starts in a city where no such certificate has been furnished and the Pullman Company is obliged to ship water at considerable expense into this city from a neighboring community which has a certificate. It seems that the embarrassment is upon the carrier rather than upon the community.

How are these certificates issued, for what period of time, and on what basis of examination?

Dr. W. H. Frost: At the present time it is merely a case of certifying water from certain sources. Certificates are issued after examinations made by state or local officials.

Mr. Philip Burgess: Not by any national officer?

Dr. W. H. Frost: No; the service calls upon state officers to make examinations of water supplies within their own states.

Mr. Wm. J. Orchard: In the New Jersey State Board of Health we had considerable opportunity to see the effect of the certificate issued to railroad companies in regard to the quality of water furnished in cars and stations. Whenever we received a request from any of the many railroads in New Jersey, for certification of a water

supply, we not only examined the records of analyses on file in our laboratory, which we are required by law to make four times a year, but we also, wherever there was any question, had an inspection made of the water shed. The speaker was of the opinion, as other men of that department were, that this matter of certifying the water supply for common carriers would tend very much to improve the character of supplies in small towns where railroads use a considerable quantity of water for their coaches and cars.

MR. GEORGE R. TAYLOR: In regard to certification in Pennsylvania, we have had considerable experience there as a private water company in making out these certificates. Many of the small towns which we supply have no local health authorities that know anything about the purity of the water, but many of these certificates have been turned over to us and signed by us, certifying that we make regular analyses of the water. In cities where we have local boards of health they have filled out these certificates, but our filling out of the certificates has been accepted by the railroad company, at least, as satisfactory. In our section no inspection has ever been made by the state health authorities.

DR. D. P. CURRY: The speaker wishes to ask two questions; they are not altogether related, but will ask both. One relates to submitting samples to the State Board of Health. Now, of course, the government has adopted an arbitrary standard, as they had to do, but the speaker cannot see the reason of the necessity of icing other samples sent to us, for in addition to that we are examining the water supply of the entire state—private wells, cisterns, streams, ponds, any source of water used or consumed by the family. Some portions of our state are seventy-two hours from the laboratory by the methods of transportation. Some are away back in the mountains. The constant complaint, when we send them a container, is "we cannot get ice." It costs too much money, and they say "will you allow us to send them in uniced by parcel post?" If it could be permitted, we could do a great deal more work. Being the only man in Kentucky excepting my assistants doing this work, it is impossible to cover the ground by personal inspection. Our analyst is not busy all the time. We want all the samples of water we can get, and we would like to ask the opinion of the men here who are familiar with the public health association whether it is possible

that samples could be sent to us from a distance, uniced, by parcel post.

We get rather an increase than a decrease of bacteria. Of course, we know that the bacteria die as the result of storage, and it is a question whether, in the course of seventy-two hours, enough of these bacteria would die out to give us a sample which did not show the pollution. We do not object to the increase of evidences in pollution in a private water supply; all we want to know is the potentiality, and it will greatly extend our work and usefulness, and also reach a great many more people in the state of Kentucky, if we can use the parcel post in sending out containers. They are very rigid about using iced samples, but that means that perhaps 30 per cent of the people of the state of Kentucky will be deprived of analyses.

In one place where there were 56 cases of typhoid fever out of 120 or more people, the speaker called to his aid the public health service rather than send uniced samples in; but at the same time did send samples by parcel post to our laboratory, and the results were absolutely identical except, of course, the results in gas. But the speaker wishes that some one here that knows a great deal more than he does about it, would contradict Dr. Frost for him, that the state of Kentucky would be justified in receiving samples for analysis without ice.

There is a condition south of the Ohio river that few men north of it can comprehend. There are whole counties without a privy attached to a school house; counties where not one house in ten has a privy of any sort. When they do have them, the privy and wells are found very close together for the sake of convenience, and it is absolutely vital and necessary to the welfare of the state that we bring to the attention of the people the fact that these wells, which apparently yield clear, sparkling water are absolutely unfit sources of water for human consumption. If we send them one of our expensive containers made in the form of an ice box, they will keep them for months at a time because they have no ice, and perhaps not one-fifth of the containers are in active use at a time. They will hold them till winter comes and then there is plenty of ice, and possibly by that time conditions in the water have changed. It is really not a small matter with our department and the speaker would like to know if the men here present think that the chances are that the pollution of water would disappear in these conditions?

The other question he wishes to submit is in regard to the advisa-

bility of reclaiming the wash water from a filter plant. One of our water companies wishes to replace the wash water, after sedimentation in a separate tank, into the raw water, and then to get rid of the sludge in the reclamation tank by drainage to low ground. There being no plants of this kind in his state he is without experience in the matter and desires the advice of someone present as to whether to allow it.

DR. EDWARD BARTOW: In a situation such as the gentleman mentions, using some of the containers we would make analyses at the end of six, twelve, twenty-four, thirty-six, forty-eight, or whatever it might be, hours, and determine for ourselves what the results were, and even if we could not conform to the standards, we would make our own standards. We would hesitate, however, to condemn a water which, after storage of four or five days, was shown to contain slight pollution, because of the great possibility of multiplication of bacteria. Care should be taken in the general condemnation of waters of that kind.

With regard to wash water there is a paper submitted by Mr. Babbitt of the University of Illinois (see page 393, vol. 2, JOURNAL AM. W. W. ASSN.), telling about the reclamation of the wash water of the Champaign and Urbana Water Company. That is not exactly parallel to the case which was mentioned. They have been able, however, to save more than 80 per cent of their wash water; allowing it to fall into a sedimentation basin and then pumping the supernatant liquid into the receiving reservoir. By the use of a little alum they are able to remove practically all of the suspended matter, and very little extra burden is placed upon the filters. With a little care, and especially with bacteriological control such an arrangement might be entirely possible in a regular filter.

MR. PAUL HANSEN: The speaker may be able to offer some slight suggestion relative to the difficulties that have been referred to. He happens to have a little familiarity with wells in Kentucky and knows that many of them are badly contaminated.

An analysis of the water is, after all, merely one point of evidence. You may get a good analysis from a well that is subject to contamination at times, so that an analysis may be quite inconclusive. On the other hand, if one knows that a well is near a privy, if one knows that it is subject to the entrance of surface drainage, and if one further

knows that a stable yard and possibly a pig pen are not very far off, there is no need of having an analysis. So that before any analyses are made at all there should be obtained a complete description of the source of supply, using perhaps blank forms for this purpose. If it is found that the source is an ordinary open type well, that it is in close proximity to various sources of contamination, one can say offhand that that well is not satisfactory because it is unquestionably in danger of contamination and that an analysis is not worth while until the sources of danger are removed.

While in Kentucky the speaker pursued that policy, and was much more certain of his judgment of the quality of water from wells than he would have been with analyses alone.

Mr. Frederick H. Stover: In reply to second question the speaker wishes to say that in the treatment of clear water he believes it is an advantage to mix the wash water with the water under treatment, because the residual coagulant present in the wash water forms a desirable matrix expediting the formation of a new floc.

Mr. Wilson F. Monfort: Some second hand experience regarding the sending of uniced samples may be of interest. There was a plant in one corner of Missouri sending samples to a state laboratory for examination. The first, the second, the third and the fourth were condemned. The fifth one arrived, was passed upon as good, with the remark, "This is the first sample we have gotten from your city which was iced." All the others had high counts and bad records. It is questionable whether you would not get too bad a result from your uniced samples. If you are limited to sending small packages by parcel post, have you considered putting your portion of media into the sterile bottle and having it incubate on the way for fermentation test only? Is it possible for you to accomplish that and have the incubation under way before the sample reaches you? The speaker is not sure that that could be worked out. You might have trouble; you might have explosions; you might have leakage; but is there not some way of having your package so put up that you might get an enrichment on the way and examine your sample afterward. You might have to use solid media before the method could be gotten into shape. The speaker would be very doubtful about a sample by parcel post which was then submitted to the ordinary examination.

Mr. Philip Burgess: The speaker has had some experience similar to those of Mr. Monfort. He was employed by the Ohio State Board of Health for some three years to investigate the water purification plants in Ohio; and, in a number of instances, he made it a special point to send samples into the laboratory and at the same time to make bacterial tests at the plant. The tests showed conclusively that, in the summer time, even when the samples were well iced, results obtained in the laboratory may have little, if any, value, because the total number of bacteria generally increases and because B. coli sometimes increase and sometimes disappear altogether.

Where it is not possible to remain on the ground sufficiently long to complete the presumptive B. coli tests, experience indicates that satisfactory results may be obtained by inoculating the fermentation tubes and shipping the tubes by express to the laboratory, where they are incubated. Apparently similar results are obtained by this method as would be obtained if the incubation commenced when the tubes were first inoculated. Moreover, such a procedure, of course, saves considerable time in the field.

The application of hypochlorite of lime to a water supply also introduces a feature which affects the results of analysis which may be obtained on the ground or on shipped samples. The germicidal action of the hypochlorite of lime continues, and, of course, affects the shipped samples, so that a less bacterial content may be obtained when samples are shipped to and analyzed at the laboratory than would be obtained were the samples plated and incubated immediately after collection. This feature, of course, has an important effect upon the value of analyses obtained from shipped samples.

Mr. Wm. J. Orchard: It might be of interest to the gentlemen present to know that about two months ago in New Jersey, at the suggestion of Dr. Fitz Randolph, in charge of the laboratory of hygiene, there was instituted a system of shipping 250 centimeter bottles out to the various water companies, the supplies of which were obtained from deep wells and the quality of which had been ascertained pretty definitely by quarterly analyses for several years previous. These samples would be sent back to the laboratory at Trenton by parcel post. That was largely brought about in order to economize in the collection of samples, which the law required must be collected by the inspectors of the state boards of health.

The speaker is unable to report the results of this procedure, but in discussing it we decided that in the case of deep well waters, in the twenty-four to thirty-six hours that it would take for the samples to reach the laboratory, the bacteriological changes, if any, would not be of sufficient consequence to influence the interpretation of the analysis, in so far as we knew the quality of the water from several years previous work.

In regard to the other matter that the last gentleman mentioned, it was our practice in New Jersey to inoculate bile tubes in the field when we were testing water supplies, and then ship them to the laboratory or carry them there in order to save time in incubation and in order to get our results sooner than we would had we waited to reach the laboratory before inoculating.

Mr. W. W. De Berard: Is there not on the market at the present time a sample bottle in which the thermos bottle principle is used? If such a bottle were filled and held for a few hours in the water of which you want a sample, so as to obtain the same temperature, the sample would probably retain that temperature for two or three days without material change.

Mr. Paul Hansen: The thermos bottle referred to by Mr. De Berard is in the office of Mr. Robert Weston, of Boston.

Mr. Wilson F. Monfort: The one referred to as coming from Kansas is gotten up by Mr. Young and two or three others at Independence, but that, however, requires ice. It is simply a fireless cooker proposition that carries four or more ordinary sized bottles. The one that Mr. Weston uses is a stock thermos bottle, and carries from three to eight two-ounce glass stoppered bottles. The quart size is not large enough to take a number of four-ounce bottles, but would take a single unit for each sample if you are sending the ordinary four-ounce bottles.

HOW TO DETERMINE THE SIZE OF TAP AND METER

By Jacob Klein

Up to recently a rule was in force permitting only one $\frac{5}{8}$-inch tap for each 25 foot frontage, no matter whether the building was two stories or twelve stories high. There was no way out of it for the consumer except to agree to install meters for the entire supply, when an additional tap or a larger tap in the place of the one in use would be granted.

Careful studies have been made to arrive at a fair basis of determining the size of tap for all classes of buildings, and it was found that the only fair and equitable basis was the "floor area basis," and early last year a rule was adopted by the water department which permits the use of a $\frac{5}{8}$-inch tap for the first 7500 square feet of floor area, a $\frac{3}{4}$-inch tap for the first 15,000 square feet and above 15,000 square feet one $\frac{5}{8}$-inch tap for every 10,000 square feet of floor space, computed as follows:

Up to 7,500 square feet................	One $\frac{5}{8}$-inch tap
7,500 to 15,000 square feet................	One $\frac{3}{4}$-inch tap
15,000 to 20,000 square feet................	Two $\frac{5}{8}$-inch taps
20,000 to 30,000 square feet................	Three $\frac{5}{8}$-inch taps or equivalent
30,000 to 40,000 square feet................	Four $\frac{5}{8}$-inch taps or equivalent
40,000 to 50,000 square feet................	Equivalent of five $\frac{5}{8}$-inch taps.

The floor space is computed by multiplying the area which the building occupies by the number of floors, exclusive of the cellar. The area of the building is computed from the general overall dimensions exclusive of small projections, such as bay windows, porches, etc. An extension to be included in the floor space must be at least 150 square feet per floor. The resulting figures are called the next higher even thousand; viz., 217,500 is considered as 218,000 square feet. No building is granted more than four taps, except upon written application accompanied by plans and specifications upon which is shown and described specifically the nature or class of business to be conducted and the purpose for which the water is required. The total number computed is reduced to equivalents. Buildings hav-

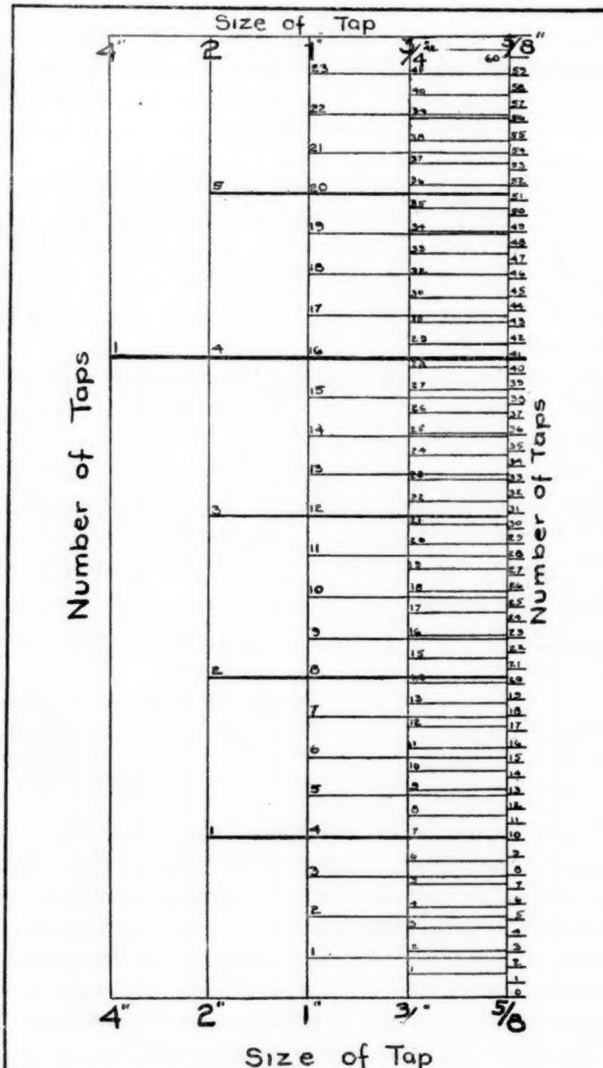

DIAGRAM SHOWING
ALL COMBINATIONS OF STANDARD TAPS
HAVING AREAS EQUAL TO
ANY GIVEN NUMBER OF 5/8" TAPS
Scale 1" = 1'
Sept 10, 11

ing floor space of less than 7500 square feet are granted an additional $\frac{5}{8}$-inch tap, provided it is found that the pressure under which the water is delivered through the main which supplies the building is not sufficient to raise water throughout the building without the aid of a pump.

It is sometimes found necessary to give applications for taps to supply breweries, ice houses, laundries, power plants, etc., special consideration as the floor area rule cannot always be applied to them. The contractor or plumber is required to file plans and specifications, showing the nature of business to be conducted and the purpose for which the water is required; also the quantity of water required per hour. These are investigated and a report stating the reasons for granting a larger size tap is filed simultaneously with the issuance of the permit.

The size of tap for fire purposes is determined by the capacity of the fire pump, or by the number of sprinkler outlets.

The standard sizes of taps in use are $\frac{5}{8}$, $\frac{3}{4}$, 1 and 2-inch. In Brooklyn $1\frac{1}{2}$-inch taps are also used. The standard sizes for connections or "wet connections" are 2, 4, 6 and 8-inch. The sizes of meters are $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, 3, 4, 6-inch, etc.

A 1-inch is the largest screw tap allowed on mains 8 inches in diameter or less. A 2-inch screw tap is made on mains 10 inches in diameter or over. Taps larger than 2 inches are wet connections.

Although there is no rule which makes it compulsory for owners of premises which face two streets to have a supply from each street the consumers are advised to do this, so that the least amount of inconvenience is experienced when it becomes necessary to shut down a main in one street. It is required, however, that in such cases a check valve be placed on each service pipe to prevent back pressure.

The size of the meter is determined by the size of the tap. A meter of the same dimensions as the tap, or *one* size larger only is permitted, but in no case may the meter be of smaller size than the tap. The rule limiting the meter to *one* size larger than the tap or connection is on account of the fact that a large meter when supplied through a small tap will not register correctly. Consumers in nearly all cases avail themselves of the privilege of using a meter one size larger than the tap.

DISCUSSION

MR. WILLIAM LUSCOMBE: It would seem that, while that might be a good way of determining the size of the taps, yet there is another very important factor that should be considered, namely, the number of fixtures, the kind of fixtures and for what purpose the water is to be used. We all know of buildings that have large floor space where little or no water is used; and on the other hand, buildings of very limited floor area where the registration of meters applied to the service is comparatively great. The fixtures, faucets, valves, etc., and the purpose or purposes for which the water is to be used should also be considered as governing factors, as well as the floor space.

FRANCHISES OF PUBLIC UTILITIES AS THEY WERE AND AS THEY ARE

By Henry C. Hodgkins

The developing and perfecting of what the real estate man calls modern conveniences and of those structures necessary for furnishing the means for the employment of these conveniences, which the publicist calls public utilities, have been so rapid and have become so necessary to every human habitation that public utilities and their franchises are receiving the widest publicity and attention as a great economic question. It is the purpose of this paper to consider only such utilities as are ordinarily within the limits of the municipality.

Mr. D. F. Wilcox makes the following list of municipal utilities: electric light and power, telephone, telegraph, electrical signals, electrical conduits, water supply, sewerage, central heating, refrigeration, pneumatic tubes, oil pipe lines, and artificial and natural gas. To these the statutes of some of the states have added street railroads, storage and wharfage.

We can better appreciate the relation of these utilities to the public and the engineer by knowing something of their history.

PNEUMATIC TUBES

Mail was transmitted about ½ mile through a pneumatic tube as an experiment in the years 1893–1898. In 1908 there were 42.2 miles, all operated by private companies under contracts with the government.

CENTRAL HEATING

Central heating is said to have been in successful operation since 1877. In 1902 there were 130 plants, of which 82 were operated in connection with other utilities.

SEWERS

Time will not permit to enter upon this subject, but the author will merely state in passing that the municipal year book of 1902

gave 47 cities and towns as having sewerage systems operated by private companies under franchises.

TELEGRAPH

The telegraph was invented about the middle of the nineteenth century. The Western Union Telegraph Company was incorporated in 1851, under the name of the New York and Mississippi Valley Printing and Telegraph Company, and assumed its present name in 1856.

SIGNALING SYSTEM

Signaling systems were developed with the telegraph. A great variety of wire signaling systems have been evolved. The wireless systems have hardly reached the classification of municipal utilities.

TELEPHONE

The first regularly equipped commercial exchange was in New Haven in 1878. From then until 1894, the date of the expiration of the patents, the business of the country was controlled by the Bell Telephone Company.

ELECTRIC STREET RAILWAYS

Electric trolley roads were first put into operation about 1888. The first one was in Iowa, at Des Moines, the second one, at Richmond, Virginia, was completed in 1888. There were others following closely. The writer's diary for 1888 states that in June, on a trip to see President Wilber of the Lehigh Valley Railroad in regard to a steam road, he stopped at Scranton to see an electric trolley in operation. They had only a few cars. There were also cars in operation in Wilkesbarre and they had difficulty with the trolley, and at corners a man would climb to the top of the car to keep the trolley in contact with the wire.

ELECTRIC LIGHT

The first central station operating electric arc lamps was installed in San Francisco in 1879, the Brush system. The Edison system of incandescent lighting was first put into operation in connection with central station lighting in 1880. It was not until some years later that the alternating current became a commercial possibility. In

1888, the writer installed a central station alternating machine at Rochester, Minnesota. At that time the Thompson and Houston Company, the predecessor of the General Electric, would give no guarantee whatever for their alternating dynamo, not even that it would generate the current.

In 1902 there were 3620 central electric lighting stations; in 1907 there were 4714 central electric lighting stations; in 1902 there were 815 or 22½ per cent owned by cities. About 1907 the hydro-electric commission of Ontario was in operation and had contracted for 100,000 h. p. at Niagara Falls and Toronto had contracted for 15,000 h. p. at $14.75 to $17.75.

GAS

Richmond, Virginia, may claim to be the first city in America to be lit with gas. "As early as 1800 a tower some 40 feet high was erected and the numerous jets that surmounted it were lit from gas generated below, by a process invented by a man named Henfry. It proved of no value."

Gas is said to have been used for lighting in Manchester, England, about 1804–1805. In 1813 it was used for lighting London Bridge. In the United States a man in Newport, Rhode Island, lighted his premises with gas in 1806. A gas company was organized in Baltimore in 1816. Boston and New York 1822–1823, Brooklyn and Bristol, 1825, New Orleans 1835.

The early history, so far as available, was a series of failures. The first public gas light in Boston was in 1829. Gas sold at $5 to $6 per 1000 cubic feet. In 1850, according to the federal census, there were 30 gas plants. The writer for a time owned a plant that was built in 1851. In 1900 there were 877 gas works.

WATER WORKS

Water works are the oldest of all municipal utilities. Water by some means has always been supplied, but it is only since about 1800 that it has been supplied in this country through regular systems of piping.

According to the *Manual of American Water Works of 1890–1891*, there were in the United States in 1800, sixteen water works of which one was owned by the public and fifteen by companies.

The increase for the next fifty years was slow.

In 1850 there were 33 public and 50 private; in 1875 there were 227 public and 195 private; in 1880 there were 293 public and 305 private; in 1890 there were 878 public and 1159 private; in 1897 there were 1690 public and 1489 private.

In Canada in 1890 there were 59 public and 36 private; in Canada in 1897 there were 109 public and 35 private.

There has been no compilation of water works statistics since 1897. The number of works has greatly increased, and the ratio of public to private works has also greatly increased, both from new construction and purchases by cities of private works.

It is therefore apparent that private capital has taken the initiative in all the municipal utilities, and, with the exception of water works, still remains in the possession and operation of a large proportion of the municipal utilities. Probably more than 90 per cent of all municipal utilities, outside of water works, are operated by companies. In this connection the writer would call your attention to the statement that prior to 1880 there were probably not to exceed 700 of what we call municipal utilities in existence in this country, and in 1850 only about 120. The question of rights under which these companies operated was not regarded of great importance prior to 1880.

The inventions of recent years, and the demand for all sorts of conveniences, have so increased the utilities that it is essential to the engineer to understand the franchises under which they operate.

Finch gives the following definition: "A franchise is a royal privilege in the hands of a subject." This definition was accepted by Blackstone and others. Another definition by Kent is that franchises are certain privileges conferred by a grant from the government and vested in individuals.

A definition generally accredited to Chief Justice Taney of the United States supreme court is, "Franchises are special privileges conferred by the government on individuals and which do not belong to the citizens generally of common right."

The word franchise is frequently used to denote a right or privilege, in a legal sense franchise and liberty are said to be synonymous.

The definition by Finch has been criticised as not being strictly correct under our government and laws, since franchises are based in this country upon contracts between the sovereign power and private citizens made upon a valuable consideration for purpose of public benefit as well as individual advantage, and it is said by Chancellor

Kent, "Franchises contain an implied contract on the part of the government not to invade the rights vested, and on the part of the grantees to execute the conditions and duties prescribed in the grant."

Distinction should be made between corporate franchises and special franchises. A corporate franchise is the right to exist as a corporation and do the business specified. A special franchise is, for example, the right to enter upon highways, public grounds, etc., and place certain structures thereon.

Much confusion has existed as between a contract and a franchise for the reason that both are frequently embodied in the same ordinance. As stated by Chancellor Kent, a franchise generally contains an implied contract or covenant, but a contract to render a specific service as, for example, lighting of streets or water for fire protection is not a franchise, although a franchise may be and generally is necessary for carrying out the contract.

For the purpose of comparison and also to show what the general provision of statutes has been regarding franchises the following table was compiled from information obtained from the two volumes of *The Law of Incorporated Companies Operating Under Municipal Franchises*, by Allen R. Foote, and Charles E. Everett, which brings the subject down to 1892.

In 41 states in the table, the length of time for which a franchise may be granted according to the general law is unlimited in 16 states; in 18 states franchises may be perpetual. In 5 states franchises are granted by special charters and no limit is mentioned. In 27 states the length of time for which a contract could be made is not limited by the general law.

In Nebraska a contract must provide for purchase after ten years. In Wyoming a franchise must contain the express condition that the municipality shall have the privilege of purchasing after twenty years.

Pennsylvania and Ontario are the only instances where the terms of purchase are explicitly stated and they are so widely divergent that the writer will give each of them. In Pennsylvania "A municipality may, after twenty years, become the owner of a gas or water company on paying therefor the net cost of erecting and maintaining the same, with interest thereon at the rate of 10 per cent per annum, deducting from said interest all dividends theretofore declared."

STATE	LENGTH OF FRANCHISE	PERPETUAL	LENGTH OF CONTRACT	REMARKS
Alabama	No general law. Usually 25 years.	Not perpetual.	As agreed.	
Arkansas	No general law.	Not perpetual.	As agreed.	
California	Not to exceed 25 years.	Not perpetual.	As agreed.	
Colorado	20 years Denver. 25 yrs. for water and gas. Gas other places.	Not perpetual.	1 year.	
Connecticut	Special charters			
Delaware	Special charters.		No limitation.	Unless specified in city charter.
Florida	Special charters	May be perpetual.	No limitation.	Legislature has limited corporate exemption to 20 years.
Georgia	Usually granted for definite time.	May be perpetual.	No limitation.	
Idaho	50 years.		50 years.	
Illinois	Street railways 20 years. Others no limit.	May be perpetual.	No limitation.	Limited as to city debt.
Indiana	No limitation.	May be perpetual.	No limitation.	Limited as to city debt.
Iowa	25 years,		Implied 25 years.	
Kansas	20 years.		Implied 20 years.	
Kentucky	20 years.		Implied 20 years.	
Louisiana	99 years.		No limitation.	
Maine	As granted.	May be perpetual.	No limitation	
Maryland	No limitation.	May be perpetual.	No limitation.	
Massachusetts	No limitation.	May be perpetual.	No limitation.	Law seems to provide for free water for fire purposes.

Michigan	No limitation or for 30 years.	May be perpetual.	30 years.	
Minnesota	50 years.	Not perpetual.	No limitation.	No special provision for contract.
Mississippi	99 years.	Not perpetual.	25 years.	If ratified by vote.
Missouri	As granted.	As granted.	20 years.	
Nebraska	First class 20 years. Second class cities water 25 years, gas 21 years.		Implied 25 years.	If ratified by vote, and reserves right to purchase after 10 years.
Nevada	No limitation.	May be perpetual.	As agreed.	Franchise granted for all sorts of purposes. City contract not required.
New York	Gas and electricity 50 years; may be renewed	May be perpetual.	5 years.	Contract not to exceed $2\frac{1}{2}$ mills on $1 of taxable property and may be for not exceeding 30 years if ratified by vote.
New Hampshire	No limitation.	May be perpetual.	No limitation.	
New Jersey	No limitation.	May be perpetual.	No limitation.	
North Carolina	60 years.		No limitation.	
Ohio	Street railways 25 to 50 years.	May be perpetual.	10 years.	Contract for water may be for 20 years if ratified by vote.
Pennsylvania	No limitation.	May be perpetual.	10 years.	
Oregon	No limitation.	May be perpetual.	No limitation.	
Rhode Island	25 years.		No limitation.	
South Carolina	No limitation.		No limitation.	
South Dakota	Street railways 20 years. Others no limitation.	May be perpetual.	No limitation.	

STATE	LENGTH OF FRANCHISE	PERPETUAL	LENGTH OF CONTRACT	REMARKS
Tennessee	Perpetual; subject to repeal.		No limitation.	Constitution prohibits perpetuities.
Texas	50 years.		No limitation.	
Vermont	No limitation.		No limitation.	Gas companies are authorized to do electric lighting.
Virginia	No limitation.		No limitation.	
West Virginia	No limitation.	May be perpetual.	No limitation.	
Wisconsin	Gas 50 years. Others no limitation.	May be perpetual.	No limitation.	Contract with gas company 10 years.
Wyoming	Street railways 10 years. Water 20 years.		10 years for water.	Franchise for water must be ratified by vote and must contain right to purchase within 20 years.
Ontario	50 years.	50 years.	10 years.	
Quebec	50 years.	50 years.		

In Ontario: "The arbitrators in determining the amount to be paid for such works, gas or water, and property, shall first determine the actual value thereof, having a regard to what the same would cost if such works should be then constructed, or such property then bought, making due allowance for deterioration, wear and tear and making all other proper allowances, and shall increase the amount so ascertained by 10 per cent thereof which increased sum the said arbitrators shall award as the amount to be paid by the corporation to said company, with interest from date of their award."

EXCLUSIVE FRANCHISE

Many companies held that their franchises were exclusive. The New York state court of appeals, in the case of the Syracuse Water Company vs. the City of Syracuse,[1] decided, "A franchise to be exclusive must therefore be given by the terms of the grant, otherwise it is not a resultance from its nature." This case was carried to the supreme court of the United States and by that court was dismissed.

Therefore there are probably very few, if any, exclusive franchises, but there are probably a good many perpetual franchises.

The length of contracts for public services has been fixed by the local authorities even where the statutes placed no limitations. Some were made for only one year at a time, a great many were made for twenty years and a smaller number for twenty-five or thirty years.

The history of American water works is the most fruitful field for the study of franchises, owing to the fact that such a large number of works have been constructed under franchises, and, after being operated during the term of the franchise or of a long contract, have passed to the possession of the municipality, and in some instances have been forced out of existence by the competition of additional works built by the municipality. In granting these franchises it was the custom in many cases for the city to employ an engineer to lay out the system of pipe distribution, specify the reservoir or standpipe and the pumping machinery, and prepare the franchise, and then call for bids on a hydrant rental basis. In some cases complete detailed specifications were embodied in the contract. The usual custom was to provide a test of fire streams which really measured the capacity of the works. In the writer's experi-

[1] 116 New York, page 167, October, 1889.

ence these tests ranged from 4 streams 80 feet high in some small places to 30 streams 100 feet high, as at Peoria, Illinois. Complete schedules of rates to private consumers were as a rule embodied in these franchises, and as a general rule the right or option to purchase was reserved to the municipality.

During the ten years from 1880 to 1890, over 850 works were built under franchises, and, as the hydrant rental contracts were mostly for twenty years or under, these contracts have expired, and in a large number of cases the works have passed to the ownership of the municipalities.

Of the over 60 places of the writer's experience nearly 90 per cent have passed to the ownership of the municipalities.

Of the 12 places in Canada only one remains in the hands of a company.

Of the 10 electric plants, 7 are still owned by companies.

It is well to stop and consider the element of time in these matters. A majority of these utilities have been evolved and made practicable within the life-time of most of us, and it is less than the span of a generation since the terms of municipal franchises were charged with being in conflict with the interests of the public. In fact it was not so much franchise seekers as it was a seeking after those who would accept of franchises. As has been shown, time limit was lightly considered, and the limitations that were made were due more to a confusion of terms than to intent to cause the demise at specified date. As time passed and the business of franchise companies developed to a profitable basis, a change in sentiment was brought about. A fierce strife between the municipality and the utility corporation occurred in many instances; a clamor for shorter contracts and a definite term for franchises, fixing a date when the utility must cease to exist and its funeral obsequies be celebrated. The fallacy of such reasoning was soon evident. For the state to kill its own creation at a fixed date only to replace it by a similar creation which might, perchance, pass to the same hands as the owners of the late deceased was absurd. Moreover utilities must not cease to exist. To shut off the city's light would be a calamity; to deprive it of water would mean famine; to stop the flow of gas means freezing, and to interrupt the telephone service would be an intolerable inconvenience. Utilities are absolutely essential. They must be maintained and operated in the most certain and efficient manner, and must continue indefinitely, or until something better

has developed that can take their place. In plain language, a utility can not be divested of its franchise and the only way a franchise can in equity terminate is by the property going to the source from which the franchise emanated.

The writer has due regard for the many able minds that believe that the term of a franchise should be short and definite. Their position is, however, entirely untenable unless they provide for the orphaned property after its right to live and be utilized has terminated.

All these considerations are bringing about a change in the manner in which public utilities are regarded. Public service commissions are becoming the rule.

The railroad commission of Wisconsin was established in 1905 and two years later was given jurisdiction over all public utilities. The law in the state of New York establishing two public service commissions was enacted in 1907, during the administration of Governor Hughes. This law as amended in 1910 is used as an argument in many of the states for similar laws. The rapid spread of commission legislation; the vast number of decisions of different commissions reasoning from different viewpoints; the very considerable contribution by engineers on the terms of regulation, valuation and rates has created a mass of literature scattered through pamphlets, society reports, etc. This mass of material has yet to be compiled and made available for the guidance of the interests affected.

In 1913 The National Civic Federation published a work entitled *Commission Regulation of Public Utilities*. "A compilation and analysis of the laws of 43 states and of the federal government for the regulation by central commissions of railroads and other public utilities." From this work and an article in the *Annal* by I. L. Sharfman, much of the following information was obtained.

Since 1913 two states have established commissions and seven others have added largely to their statutes. Delaware, Utah and Wyoming[2] are the only states having no central commissions. New York, Massachusetts and South Carolina have each two commissions and in Massachusetts the telephone and telegraph are under the jurisdiction of the highway commission.

The following table shows the utilities of each state which are under the jurisdiction of their respective commissions.

[2] Law providing for commission passed in 1915.

	COMMON CARRIERS	STREET RAILROADS	TELEPHONE	TELEGRAPH	GAS	NATURAL GAS	ELECTRIC LIGHT	WATER	POWER	HEATING	IRRIGATION	PIPE LINES	STORAGE	WHARFAGE	TRANSMISSION
Alabama	—	O	—	—	O	O	O	O	O	O	O	—	O	O	O
Arizona	—	—	—	—	—	O	—	—	O	—	—	—	O	O	O
Arkansas	—														
California	—	O	—	—	—	O	—	O	—	—	O	O	—	—	O
Colorado	—	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Delaware															
No commission															
Connecticut	—	—	—	—	—	—	—	—	O	O	O	O	O	O	—
Florida	—	O	—	—	O	O	O	O	O	O	O	O	O	O	O
Georgia	—	O	—	—	—	O	—	O	—	O	O	O	O	—	O
Idaho															
Illinois	—														
Indiana	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Iowa	—	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Kansas	—	O	O	O	O	O	O	O	O	O	—	—	O	O	O
Kentucky	—	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Louisiana	—	O	—	—	O	O	O	O	O	O	O	—	O	O	O
Maine	—	—	O	O	O	O	O	O	O	O	O	O	O	O	O
Maryland	—	—	—	—	—	—	—	—	—	—	O	O	O	O	O
Massachusetts															
Gas and Electric					—		—								
Railroad Commission	—	—				O		O	O	O	O	O	O	O	O
Highway Commission			—	—											
Board of Health								—							
Minnesota	—	O	O	O	O	O	O	O	O	O	O	O	—	O	O
Mississippi	—	—	—	—	O	O	O	O	O	O	O	O	O	O	O
Missouri	—	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Montana	—	—	O	O	O	O	O	O	O	O	O	O	O	O	O
Nebraska	—	—	O	O	O	O	O	O	O	O	O	O	O	O	O
Michigan			—	—	—	—	—	—	—	—	O	—	O	O	—*
Nevada	—	O	—	—	O	O	O	O	O	O	O	O	O	O	O
New Hampshire	—	—	—	—	—	—	—	—	—	—	O	O	O	O	O
New Jersey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O
New Mexico	—	—	—	—	O	O	O	O	O	O	O	O	O	O	O
New York	—	—	—	—	—	—	—	O	O	O	O	O	O	O	O
North Carolina	—	—	—	—	O	O	O	O	O	O	O	O	O	O	O
North Dakota	—	O	—	—	O	O	O	O	O	O	O	O	O	O	O
Ohio	—	—	—	—	—	—	—	—	—	—	O	—	—	—	O
Oklahoma	—	O	O	O	—	O	—	O	—	—	O	O	O	O	—
Oregon	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pennsylvania	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—
Rhode Island	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—

	COMMON CARRIERS	STREET RAILROADS	TELEPHONE	TELEGRAPH	GAS	NATURAL GAS	ELECTRIC LIGHT	WATER	POWER	HEATING	IRRIGATION	PIPE LINES	STORAGE	WHARFAGE	TRANSMISSION
South Carolina															
Railroad Commission	–	o	–	–											
Public Service Commission............					–	–	–	–	o	o	o	o	o	o	†o
South Dakota.........	–	–	–	o	o	o	o	o	o	o	o	o	o	o	o
Tennessee.............	–	o	o*	o	o	o	o	o	o	o	o	o	o	o	o
Texas.................	–														‡
Utah															
No commission															
Vermont.............	–	–	–	–	–	o	–	o	–	–	o	o	o	o	o
Virginia...............	–	–	o	o	–	o	–	–	–	–	o	–	o	o	–
Washington...........	–		–	–	–		–	–	o	o	o	o	o	–	–
West Virginia.........	–	–	–	–	–	–	–	–	–	–		–	–	–	–
Wisconsin.............	–	–	–	–	–	–	–	–	–	–	o	–	–	–	–
Wyoming															
No commission. Law passed at 1915 session of legislature															

* New law goes into effect September 1, 1915.

o indicates no control.

– indicates control by commission.

† Does not apply to Charleston, Marion, Spartanburg, Sumter, Union or town of Conway.

‡ New law being prepared during winter of 1915. (Law passed and took effect 90 days after adjournment of Legislature.—Editor.)

Twenty-four states make express provisions for the valuation of properties of public utilities by the commissions.

Arizona	Maryland	Oklahoma
Arkansas	Massachusetts	Oregon
California	Michigan	Pennsylvania
Florida	Minnesota	South Dakota
Georgia	Mississippi	Texas
Illinois	Nebraska	Washington
Indiana	New Jersey	West Virginia
Kansas	Ohio	Wisconsin

Rates must be just and reasonable. A reasonable average return upon the value of the property actually used in the public service

and the necessity of making reservation out of income for surplus and contingencies are generally recognized. Unjust discrimination is almost invariably prohibited. Publicity in the establishment and change of rates is as a rule required.

Authority to fix, establish or prescribe rates and charges is given in 24 states.

Arkansas
Florida
Georgia
Illinois
Iowa
Kansas
Louisiana
Michigan
Mississippi
Missouri
Montana
Nebraska
Nevada
New Mexico
New York
North Carolina
North Dakota
Oklahoma
South Carolina (does not apply to Charleston, Marion, Spartanburg, Sumter and Union or the Town of Conway)
South Dakota
Tennessee
Texas
Virginia
Wisconsin

Authority to regulate accounts, etc., is given in 27 states.

Alabama
Arizona
California
Connecticut
Florida
Georgia
Iowa
Kansas
Maryland
Massachusetts
Michigan
Minnesota
Nebraska
Nevada
New Hampshire
New Jersey
New York
Ohio
Oregon
South Dakota
Texas
Vermont
Washington
Wisconsin
Indiana
West Virginia
Illinois

Depreciation accounts are mandatory in Ohio and Wisconsin, and the commission may require them in Arizona, California and New Jersey. Recent statutes provide for depreciation accounts in Idaho, Illinois, Indiana, Mississippi and Pennsylvania and Michigan.

In 18 states the consent of the commission is necessary to authorize the issue of stock and bonds.

Arizona
California
Georgia
Kansas
Maryland
Massachusetts
Michigan
Nebraska
New Hampshire
New Jersey
New York
Ohio
Texas
Vermont
Wisconsin
Illinois
Indiana
Pennsylvania

A certificate of convenience and necessity is required in 20 states before commencing operations under a franchise.

Arizona	Michigan	Idaho
California	New Hampshire	Illinois
Connecticut	New York	Indiana
Kansas	Ohio	Mississippi
Maine	South Dakota	Pennsylvania
Maryland	Vermont	West Virginia
Massachusetts	Wisconsin	

Indeterminate franchises are provided for in Massachusetts and Wisconsin and by recent legislation, according to Sharfman, in Idaho, Illinois, Indiana, Missouri, Pennsylvania and West Virginia.

Perhaps the most explicit, at least the most notable, of the public service commission laws is that of Wisconsin. The Wisconsin law provides:

> Every license, permit or franchise hereafter granted to any public utility shall have the effect of an indeterminate permit, subject to the provisions of this act, and subject to the provisions that the municipality in which the major part of its property is situate may purchase the property of such utility actually used and useful for the convenience of the public at any time as provided herein, paying therefor just compensation to be determined by the commission and according to the terms and conditions fixed by the commission. Any such municipality is authorized to purchase said property, and every such public utility is required to sell such property at the value and according to the terms and conditions determined by the commission herein provided.
>
> Utilities existing at the time of the passage of the act could, prior to July 1, 1908, surrender their franchise and receive an indeterminate franchise or permit.
>
> The commission shall value all the property of every public utility, and may at any time on its own initiative make a revaluation of such property. The commission may fix such rates as are just and reasonable.

In the state of New York, with the exception of water works, practically all municipal utilities come under the provisions of the public service commission law.

Under this law the commission has power to fix the standard for gas and to order improvements and extensions; to prescribe the efficiency of the electric supply system, of the current supplied and the lamps furnished; to require gas to equal the standard fixed, and prescribe the maximum and minimum pressure. Charges for gas

and electricity shall not exceed those fixed by law or by the order of the commission and shall be just and reasonable. Require uniform system of keeping accounts. No gas or electrical corporation shall begin the construction of gas or electrical works without the permission and approval of the commission. The commission may grant permission and approval if such construction be found necessary or convenient for public service. No municipality shall build, maintain and operate any works or system for manufacturing and supplying gas or electricity for other than municipal purposes without a certificate of authority granted by the commission.

The commission's consent is necessary for the issue of bonds, stocks and notes.

Practically the same provisions apply to the construction of steam heating plants under a franchise or by a municipality.

Telegraph or telephone companies must have a similar certificate of necessity before constructing under a franchise.

Water works and water supplies in New York state are under the jurisdiction of the conservation commission.

All plans for a new or increased water supply must be approved by the conservation commission before works can be constructed either by a municipality or by a company under a franchise.

While franchises in Wisconsin have been made indeterminate, the length of time for which franchises may be granted in New York does not appear to have been changed.

By referring to the table it will be seen that only 15 states have placed water works under the control of their commission. Fifteen have placed practically all other utilities under commissions and in all of the 45 states the railroads are under commission control.

A study of the statutes reveals but little tendency toward shortening the duration of franchises, but on the contrary a tendency toward prolongation or, as in the case of Wisconsin, of indeterminate franchises. The indeterminate franchise has yet to win its place, although judging from recent legislation, it seems to be growing in favor. So far it is the only answer that has been made to a much vexed question. Many able lawyers have asked, "What are you going to do when your franchise expires?" And when the franchise has expired and even before, competing franchises have been granted with the result that the owners of one have purchased the other, thereby continuing with increased capitalization the previous conditions. In some cases where there was a contract for public service, as in the case of water or electric light, the municipality has

constructed works on the theory that the expiration of the contract terminated the franchise and all right to do business thereunder. Neither of these conditions is desirable. They never have resulted, and they never will result in benefit to the public at large.

With the franchises terminating at a fixed date, with no provision beyond that date, capital will grow more and more timid as that date approaches, with the consequence of a much rundown property and the poorest service that can, under the circumstances, care for the business. This has been demonstrated in many instances. To insure the proper maintenance and operation of utilities capital must be made secure not only up to but beyond any date that may be fixed.

The municipalizer will say that the remedy for all this is public ownership; and with public ownership properly acquired he is agreeing with all that has been said in this paper.

Some one has said, "Public utilities must be controlled and regulated by government, or must be left to do as they please or must be operated by the public." That they can be left to do as they please no one will contend. That they can be operated by the public is, of course, possible, but public ownership in the great majority of utilities is not here nor is it likely to be in the near future. Public ownership of water works exists in large and increasing numbers, and ownership of other utilities exists and will very likely increase. As engineers and managers we have to face both conditions. Towns that own their water works will not own any other utility; towns that own police and fire alarm systems will not own other signaling systems; towns that own the electric light plant will not own the gas plant; and towns that own the telephone system will not own the telegraph.

The question then is not how shall utilities operated under a franchise be controlled, but rather how shall utilities be controlled whether publicly or privately owned.

As a fundamental principle they should each be controlled and operated under the same rules and regulations. It will be argued that publicly owned utilities should not be operated for profit, while those privately owned are operated for that express purpose.

Every business will either show a profit or a loss and every utility, whether public or private, should be planned to show a balance on the credit side; in other words the maintenance and operation of no utility should be a charge on the general tax budget. Therefore the method of accounting should be the same in either case.

Every utility should be charged with the following:

Taxes on the same basis as other property.

Accident insurance.

Fire insurance.

All damages not covered by insurance.

Water, light, heat, telephones, etc.

Rental of offices and buildings, whether owned by the city or not, unless they are owned by the utility.

Interest on bonds, notes and other liabilities.

Legal expenses and services, even though performed by city attorney.

Engineering expenses and services, even though performed by the city's engineers.

Depreciation and sinking fund charges.

All utilities using the public streets should be charged, in addition to the repairs they are compelled to make, with an annual tax, depending on the character of the utility, to be paid into a pavement repair fund.

Every utility should be credited for every public service rendered, such as:

Fire protection.

Water for schools, fountains, street sprinkling and sewer flushing.

Electricity, gas, heat, telephones, etc.

Use of poles by other utilities.

Transportation of city employees and material not otherwise paid for.

Quoting from an article by John S. Kennedy in the *Forum:*

> In some cases the affairs of the lighting plants are so interrelated with those of the water or some other department that it is impossible to determine the actual results of the operation of either department. The commission, New York state, remarks that it is a matter of supreme importance, when municipalities embark in business enterprises, that they should adopt businesslike methods. The citizens of many a village are convinced that their lighting service is cheap when, as a matter of fact, it is dear, because the lack of proper accounting system fails to reveal the actual conditions.

All plans for construction of privately owned utilities should be approved by the city's engineers or be in accordance with general specifications prepared by the city, and where approval by state officials is required the same rules should apply whether the utility is to be publicly or privately owned.

The attitude of the manager or the engineer toward his property should be the same whether publicly or privately owned.

Efficiency in management should be secured in either case, and the reward of efficiency should be freely conceded not only to the manager but also to the capital which took the risk and produced the utility. This reward should accrue to the respective owners whether they be a corporation or a municipality. The writer is aware that this latter proposition will call forth loud protestation, but he would call attention to the fact that from 60 per cent to 75 per cent of the population of every city live in rented houses and pay but little or no taxes. If a municipally owned utility is established it is the property owner who takes the risk and stands the loss. Therefore if the utility is a success the property owners should receive the benefit the same as though they were stockholders in a corporation. The proposition that municipally owned utilities should not be operated for profit is a delusion and a snare.

The proposition is boldly made that the rates for every municipally owned utility should be fixed on the basis of returning a reasonable profit. Take for example a telephone system. Fully two-thirds of the users are not taxpayers. If an unlimited suffrage compels municipal ownership, placing the risk of loss and all incidental expenses upon the realty, should not the rates be fixed so as to bring its ultimate reward in the shape of a surplus to the city treasury?

If a municipality is to engage in the business of any utility it should be required to first acquire the property of the particular utility then in existence. There may be reasonable exceptions, as in the case contemplated by the New York law, for a city to light its own streets without being required to engage in commercial lighting. Any theory of municipal ownership without acquiring the property of the utility in existence at the time must, if reasoned out to a conclusion, abrogate all right of regulation or control. On the other hand the denial of the right of government regulation will surely lead to competition by the municipality with resulting waste and disaster.

As men interested in water works you will note that in only 15 states are water works placed under the control of commissions. The reason for this is probably due to the fact that in most, if not all, states water supplies and water works are to some extent under the control of the state board of health.

In addition the franchises under which water companies operate

reserve a large measure of control to the municipalities. As a rule rates which may be charged for water as well as hydrant rental are fixed for a term of years and at the expiration of the term are subject to revision under a new contract. Some writers believe that local control is the proper method, and that commission control is wrong in principle, and the much mooted question of local self government as opposed to state control comes to the front. Here again water works afford the best field for investigation, and are the most prolific in argument for each side of the case. Local control has in many cases demonstrated its futility. Either it has been so easy that the utility company has been left to do as it pleased or it has been so severe that the utility has failed to survive. As the municipality is in fact a party to a contract it can not in fairness be left to interpret and change its terms. Resort must therefore be had to the courts or a commission, and for the present the logic of events points to the commission.

In the case of the municipally owned utility the management is frequently such that regulation by a state commission has been demonstrated to be desirable. If commission regulation is necessary for companies it is also desirable for the municipality, and all utilities whether publicly or privately owned should be subject to the same regulation.

The same system of accounts, the same principles governing charges to be made and service to be rendered, should apply to one the same as to the other.

It must not be inferred from the rapid spread of commission legislation that the panacea for all franchise troubles has been found. Franchise difficulties have always existed, from the time that Moses in anger struck the rock twice, and it is not supposable that they will at once terminate. Commissions have yet to demonstrate their practicability and usefulness; their rulings and decisions are liable to error. Much will depend upon the character and ability of the men composing the commissions. With the best of intentions equitable and just results will not always result. Their work should not be speedily approved nor too hastily denounced.

The question is one that cannot be dismissed. Public and private ownership are with us, and are bound to continue in varying proportions for years and even generations. The investments in privately owned utilities are growing to enormous figures and the question of regulation must be worked out with patience, fairness and wisdom.

THE DESIGN AND OPERATION OF INTERMITTENTLY OPERATED WATER PURIFICATION PLANTS

By N. T. Veatch

In our experience in the design and operation of water filtration plants, we have learned that the plant with intermittent operation presents the most difficult problems. The practice in the past has been to depend almost entirely on the filters themselves, for the overall efficiency of the plant, and to give very little attention to the design of the settling and coagulating basins. There is little question but what the action in the basins and in the filters themselves is equally important in getting good and economical results in any filtration plant. This fact is most emphatically true of plants which are operated intermittently.

In cases where the plant is operated perhaps ten hours each day, it is difficult to get the proper conditions of water applied to the filters during the first part of each run, as the floc has almost always settled out so as to cause the first water applied to the filters to be clear, or practically so, and free from floc. The arranging of the basins so as to make it possible to handle this clear water and to prepare it for application on the filters is one of the most difficult features in the design.

It is a pretty well established fact that thorough mixing of the chemical and the raw water when first pumped into the basins is well worth the cost. There is always some question as to just how far it is wise to carry this mixing, as each water presents a separate study in itself. There are so many things that enter into the action, such as temperature, turbidity, etc., that no set length of time can be taken as the proper time for mixing. The length of time also depends on the degree of agitation. If the mixing is obtained by means of mechanically driven agitators, the time required is much less than when obtained by baffling. To meet different temperatures, and different conditions of the water, it is probably best to subject the water to at least thirty minutes of mixing when mechanically driven agitators are used, and at least an hour where

baffles are depended upon. These periods are based on the use of alum as a coagulant, and are taken from results obtained at different plants. If lime or lime and iron is used as coagulant, the length of time for mixing would vary, depending upon the results desired, such as to the degree to which it is desired to soften the water, if softening is attempted. The figures given should be considered as general only, and not be construed as the ones to use for any and all waters.

After the water has had the chemical mixed with it thoroughly, the question arises as to the best means of treating in the basins before applying to the filters. This second stage in the treatment should depend on the operation of the plant. If the operation is continuous, we find that the water should be treated in the basins in such a manner as to obtain the greatest amount of sedimentation, and at the same time carry a proper floc over onto the filter beds. In case the operation is intermittent, it is best to give the water the greatest chance for sedimentation, and not attempt to keep any floc in suspension. In this way the water at the start of any run, and at any time during the run, is as near a completely settled water as possible. This would also be the condition of a water which is subject to treatment in large settling basins, before applying to the filters.

To prepare the flocless water obtained as outlined above, for application to the filters, the best plan is to subject it to another thorough mixing. It is well to arrange this secondary mixing so that the chemical can be applied at several different points and periods before the water reaches the filters. We have found that it is convenient to be able to apply coagulant at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 hour periods, just prior to water reaching the filters. The condition of the water, and the temperature should determine the proper place for application.

This paper is meant to deal particularly with plants where the total retention period in the basins is from 4 to 6 hours. In basins of this size it is possible to use the basins as settling and also coagulating basins combined. As indicated, previously, in this paper, if the operation is continuous, the mixing at the entrance to the basins, and proper arrangement of the basins will put the water in good condition for application. However, in intermittent operation arrangements should invariably be made for applying the chemicals just prior to passing the water onto the filters. The design of this

secondary treating basin should be given very careful study, as the chemicals should all be decomposed before reaching the filters.

The question may arise as to why it is necessary to design filter plants which operate intermittently. This is a very natural question, as it is unquestionably preferable to operate a filter plant continuously. However, the matter of cost, both first cost and that of operation, must always be considered, and especially in the smaller cities. It is necessary for the engineer to compromise his ideal installation to fit the appropriation, and give his client a plant which will operate at a minimum cost. The average city of less than 3000 people does not operate its water works plant continuously, and almost invariably the entire operation is handled by one shift, and often by one man. It generally proves to be much cheaper to pay the fixed charge on the extra investment necessary to give the city a plant that will fit in with the normal operation of the pumping plant, than to cause the city to change its plan of operation, and add one or two shifts to its operating force.

With a properly designed plant which operates intermittently, the city has a plant which will fit in with its normal operation, and as the city grows nearer the size which would require the maximum capacity of the plant, it can well afford to put on the extra help necessary to operate continuously.

It is evident that there is a great need for good engineering and careful study in the design of basins, for any plant. Some of the discredit which is given to mechanical filtration could have been avoided if proper care had been given to preparing the water for treatment on the filters.

PLUMBING CODE AND CONTROL OF PLUMBERS[1]

Scotland G. Highland[2]

The object of this paper is to show that the character of private plumbing installations and the control of plumbers are matters of vital interest to water works operators; and that the responsibility of water works officials does not cease with the delivery into the street mains under adequate pressure of a clear, germ-free, wholesome water.

The water department, knowing intimately by its own investigations and by chemical analyses the character of water supplied to consumers, is in the best possible position to give advice regarding the material suitable for supply pipes.

The amount of water to be supplied at the source is always greater than that actually needed for use. There is leakage from the service pipes, and from a considerable percentage of the plumbing fixtures in the houses, and water is allowed to run uselessly from many openings. In many cities four times as much water is supplied as is actually used. The greater part is wasted without benefit. It is mainly for this reason that the control of plumbing and plumbers by water departments is absolutely essential. The unnecessary draft of water from fixtures may be checked by universal metering and the adoption of a schedule of rates by which the payment of takers is dependent upon the amount of water passing through the meters.

A comparatively small percentage of services are metered, however, and we must deal with the problem as it exists.

The official inspection of plumbing work in cities of the United States began about the year 1881. In this year, too, the first complete plumbing code was adopted and among the cities leading in this movement were Lawrence, Massachusetts, Washington, D.C.,

[1] Read at meeting of American Water Works Association, May 9 to 15, 1915, Cincinnati, Ohio.

[2] Secretary and general superintendent, Clarksburg water works and sewerage board, Clarksburg, West Virginia.

New York City, Brooklyn, New York, and Chicago, Illinois. The official control of plumbing work had for some years previously been agitated and urged by health departments and by persons interested in house sanitation.

It was but natural that the first codes were enacted and enforced by health departments. Later on, this work was shifted over in some cities to the municipal building bureaus. It was claimed by some that it was more logical to include the duty of plumbing inspection with the numerous other functions of building departments, and practical advantages as regards the filing of plans in particular, were claimed for the change in departments. Still even at this day the control of plumbing in the majority of cities, which have enacted a code, is in the hands of the health commissioners or their assistants, and this is due to some extent, no doubt, to the popular belief that there is some connection between bad or imperfect plumbing and disease.

In more recent years, some of the states have enacted laws, providing for the local control of plumbing, and have issued general rules for plumbing and water supply.

Not only the large cities of the country, but many smaller cities, towns and villages have adopted plumbing codes.

The more concise, comprehensive and brief a plumbing code, the better will it fulfill its purposes. Clearness of wording is essential. Each paragraph, each rule should be definite and there should be no doubt left as to its proper meaning. No arbitrary interpretation of a rule by the plumbing inspector should be possible.

WHY ARE PLUMBING CODES REQUIRED

The writer is a firm believer in the good results which are brought about by the enactment and enforcement of plumbingcodes. He has noted the vast improvements which have taken place in the past ten years in the character of the plumbing work as executed in all classes of buildings, and he can unhesitatingly state that these improvements are due, perhaps more than to any other cause, to the introduction of an official and honest supervision of plumbing by municipal authorities, or by water works departments.

In these years the art and craft of plumbing have made wonderful advances and credit for this also belongs, no doubt, to respectable and first-class plumbing firms to be found in every city or town, and

to the local and National Associations of Master Plumbers. But as in every herd of white sheep there may be found some black sheep, so there are plumbers and plumbers, and it must be said, sad though it is, that some men of the trade do not know, or if they know, do not wish to carry out a contract honestly and creditably, whenever there is a chance to "scamp the job." Therefore, to prevent imperfect work, plumbing must be inspected. The best men in the trade do not object to such inspection. It rather protects them against unscrupulous competitors. House owners, as well as tenants, should likewise welcome the introduction of a code, for it secures to them good and reliable work, and protection against leaks or other plumbing troubles.

Every plumbing code should require that all persons working at the business of plumbing, whether as a master or as a journeyman plumber, should have a certificate of competency, and should be registered.

To establish such competency and registration every code provides a board of plumbing examiners, before whom applicants should appear for examination, and who determine their qualification to engage in such business.

The board of plumbing examiners should consist of at least three, and preferably five, members. One of these should be a master plumber, another a journeyman plumber, both to be appointed for one year by the mayor, under approval of the city council. The other members should be city officials, preferably members of the water and sewer departments or the city engineer's bureau. The board should hold regular business meetings, institute the examinations, and issue licenses to the successful applicants. The secretary of the board should keep all records, books, plans, specifications and other papers, and should preferably be a municipal officer, or he may be the superintendent of the water department.

All licensed plumbers must be registered and should be required to execute a bond for the faithful performance of their work, the amount of the bond varying from $500 to $3000, according to the size of the city.

With the single exception of repairing leaks, all plumbing should be done only after filing plans and specifications and obtaining a proper permit from the board.

The board should appoint the plumbing inspectors. They should be selected only with reference to their fitness for the position; po-

litical favoritism should be excluded. Only by a strict adherence to this rule can an efficient corps of inspectors be maintained.

When the plumbing work in a building has been completed, tested, and inspected, the board issues to the plumber, upon his request, a certificate of inspection that the work has been properly performed as required by the provisions of the code. To make such a certificate of value to the owner of a building, it should have the signature of the plumbing inspector and of the superintendent of the water department.

WHAT CITY DEPARTMENT SHOULD CONTROL PLUMBING

The writer has already mentioned that inspection is carried out either by boards of health, or by building departments. There are, however, other municipal departments, who are interested in the plumbing code, namely: the water works department or board, the sewer department or board, the city engineer's or city manager's office, and the fire department.

There is much to be said in favor of having the plumbing controlled by a water works department, as is at present the case in Clarksburg, West Virginia. A good plumbing code is of inestimable importance to a water works department. The absolute control of plumbers is quite necessary in order that the house installation may be of a satisfactory character. This control also consists in obtaining proper reports on this installation for filing in the water department's office.

In England, for instance, the various private water companies have each its own set of very complete regulations as to the thickness, weight and quality of pipes and fittings to be used for service supply.

WHAT POINTS, BESIDES THE GENERAL ONES MENTIONED, SHOULD A CODE EMBRACE

The following are some of the essentials:

(a) It should specify the use of proper plumbing materials and require first class workmanship.

First class work implies both good materials and a careful laying out and carrying on of the work.

(b) Safety requires of the entire work freedom from leaks in supply pipes.

(c) It should strive to introduce safer, simplified and more economic plumbing systems and layouts.

(d) It should consider the possible relation between plumbing and preventable disease.

(e) It should provide proper material and sizes of service and house supply pipes, and thus insure a sufficiency of wholesome hot and cold water.

(f) It should provide proper, strong and desirable water fittings, faucets, ballcocks, tanks, etc.

(g) It should make provision against both waterhammer and noise in the house service pipes.

A good mechanic knows how to guard against waterhammer in a supply system. The entire abolishment of noises in the water pipes, boilers, and in flushing tanks is desirable, but not always easy to attain.

(h) It should guard against the freezing of water pipes and also efficiently prevent any undue waste of water.

The last two requirements are of so much importance that they will be dealt with at length further on.

In addition to the above, the plumbing code should provide that none but tappers employed by the water department should be permitted to tap any street water main.

The work of efficient municipal or private water works should not be restricted to the routine duties, which consist in providing in the city service reservoirs and in the city water mains a wholesome, germ-free supply of clear water.

Such bureaus should always have a higher aim in view, namely of having a perfect control of the supply at the house faucets, in the house storage tanks, in the basins, bathtubs or other ablution fixtures, and even of the drinking water at the consumer's table. The water delivered to the consumers should be without color, bad odor or bad taste, and free from deposits of sediment or rust in the house pipes.

Moreover, a matter of vital interest to the water department, and no less to the taxpayers, is the prevention of all unnecessary *waste of water*. This matter becomes serious, where, owing to droughts, there is a threatening shortness in the public water supply. Can it be efficiently accomplished, and if so, by what means?

Efficient water works departments have learned to cope with this question in street mains, but they should go a step further and strive

to prevent waste of water from consumers' fittings and in water takers' premises. To the average layman a slight leakage seems an unimportant matter and he is apt to overlook the fact that the effect of slight leaks, if constant, is vastly increased by the time factor. A mere dribble from a faucet, if allowed to run on unchecked for twelve months, often amounts to more than the annual tax for water. In cities and towns, where the unrestricted constant supply system is used exclusively, it is of the utmost importance that the waste be checked, however unpopular or unpleasant the application of waste-preventing measures may appear to be.

The existing water pressure has a considerable bearing upon the volume of water running to waste from defective fittings, and this is another point ignored by water takers.

While waste of water due to badly constructed apparatus, or fittings, or to defective workmanship can and is prevented by the department's plumbing supervision, where the department has the power to regulate by code the character, strength and arrangement of pipes, faucets, tanks, cisterns, fittings, boilers and plumbing fixtures, much of the waste going on in buildings is under direct control of the consumers. This refers not only to waste caused by faucets carelessly left running, but also to the waste due to *wilfully* keeping faucets open. Then we have another waste, due to running water off from the hot water faucet in cases where a circulation pipe is omitted; still another is the wilful running of faucets to get, in summer, cool water for drinking; sometimes it is caused by a cold water pipe being in contact with hot water or steam pipes or by its being carried near a kitchen or laundry ceiling, where much heat accumulates.

Consumers are likewise responsible for hidden wastes from underground service pipes which have become corroded or broken. Then there is the waste due to ordinary wear and tear, caused for instance by worn-out washers in faucets or tank ballcocks.

Fittings in private houses are much more difficult to control than those in public or semi-public buildings. Hence the water department should have proper authority to enforce a penalty for neglect of the water fittings, and also for wilful waste. In many cities and towns this is quite a customary measure of prevention.

All well-organized and efficient municipal or private water works departments issue a set of rules and regulations governing the use of water. These rules should be explicit and they must be impartially enforced. Some of the points to be covered by the rules are:

Taps and service pipes to be of size prescribed by the water department. They shall be run into the buildings only by licensed plumbers, who must file an application stating the material to be used. The connection to be inspected before being covered up to guard against poor workmanship or imperfect fittings.

All water takers are required to maintain the entire inside water system in good condition and repair. They shall also protect all pipes and fixtures from freezing.

A further precaution to prevent waste of water consists in the annual inspection of all water fittings by water department inspectors.

If space permitted, the speaker could take up numerous details regarding the water supply of buildings. Suffice it to mention but a few points.

In some English towns (like Manchester and Liverpool) all water fittings are tested and stamped by the water departments and only stamped fittings are permitted to be used. In our own country such a far-reaching control or discrimination is neither practicable nor desirable, but owners of houses should be cautioned, in their own interest, to specify or purchase only fixtures and fittings made by manufacturers of first class reputation. The difference between such fittings and cheaper ware is usually but slight, whereas the cost of removing and renewing fittings, which turn out to be defective and unsatisfactory, is considerable.

The examination, licensing and control of plumbers who wish to do any work—contract or jobbing, new work, alteration work or repairs—in connection with the water works system of a city or town, are matters of vital importance to a water department. To exercise such control without, in some cases, some friction being created is not always easy, but much can be accomplished in this direction and trouble and misunderstandings avoided by a firm and tactful conduct of the men who comprise the board.

It is decidedly to the interest of all water works plants that permission should be obtained to do work in buildings. The systematic filing of plans, of the specifications, of the record plans, showing the location of the fittings, and of diagrams, giving the number, style or type, size and material of fittings acts as a decided measure of protection to property owners. It should, therefore, be universally encouraged.

The plan which has been adopted and which is being carried out by the water works and sewerage board of Clarksburg, West Vir-

ginia, to license and control all plumbers is a thoroughly good one, and the measure is a just one, protecting as it does the water department, the conscientious and honest plumber, the realty interests and the owners and tenants of the buildings.

Some water works plants, even those where the water is purified by filtration on a large scale, fail to give entire satisfaction, because of troubles existing and persisting from the point where the water leaves the main until it reaches the consumer. Under such conditions arise numerous troubles and complaints of the water takers.

It is the business, and the duty of a progressive, broad-minded and public-spirited board to thoroughly investigate each complaint, no matter how trivial it may appear to be. Occasionally the consumer finds it necessary to complain of dirty water, and this may be caused by accumulation of deposits and rust in old, worn-out services, which cause the benefits due to the filtration plant to be lost, though there may be other causes.

The Clarksburg water works and sewerage board instituted last year a very excellent plumbing code embracing all safe and established methods of supplying water to buildings and generally all classes of work usually done by plumbers, a copy of which was furnished to every water works department in this country and Canada.

A water works department may control some of these points, and in others it can do much to retain, or regain, the confidence of the water consumer by practical advice and by intelligent and prompt action in remedying the troubles complained of.

Water pressure 105 pounds per square inch. The price per 1000 U. S. gallons, 25 cents.

WATER JUST DRIPPING

15 gallons per day.
105 gallons per week.
5,475 gallons per year.

Cost per day......	$0.00375
Cost per week.....	.02625
Cost per year.....	1.36875

WATER LEAKING THROUGH ONE-SIXTY-FOURTH OF AN INCH APERTURE.

98 gallons per day.
686 gallons per week.
35,770 gallons per year.

Cost per day.........	$0.02
Cost per week........	.17
Cost per year........	8.94

WATER LEAKING THROUGH ONE-THIRTY-SECOND OF AN INCH APERTURE.

543 gallons per day.
3,801 gallons per week.
198,195 gallons per year.

Cost per day.........	$0.14
Cost per week........	.95
Cost per year........	49.55

SECTIONS OF PIPE SHOWING SOME CAUSES OF WATER WASTE AND REDUCED PRESSURE

These illustrations show only a few of the many causes of the waste of water, as well as the reduced pressure resulting from the bad condition of service pipes and house fixtures.

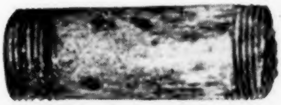

FIG. 1. THE EFFECT OF CORROSION ON BLACK IRON PIPE WHICH HAS BEEN EATEN THROUGH

This is a very common form of leakage.

FIG. 4. IRON PIPE DAMAGED BY UNEQUAL SETTLEMENT.

In this case the fracture is longitudinally along the seam and readily admits of large leaks.

FIG. 2. A LEAKING WIPED JOINT

Due to poor workmanship.

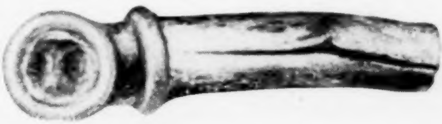

FIG. 5. COMBINATION OF CORROSION AND LEAKAGE.

This one-half inch pipe is so corroded that the opening would scarcely admit of a very small stream.

FIG. 3. EXAMPLES OF BADLY CORRODED SERVICE PIPES.

It frequently occurs that the failure of water to reach the third or even the second story of a building is caused not by lack of pressure in the street mains, but by corroded service pipes.

FIG. 6. THE EFFECT OF ELECTROLYSIS ON LEAD SERVICE PIPE.

The lead has been eaten completely away in one place, permitting a considerable leak.

In consequence of corrosion and leakage, cases are frequently found where the pressure on the street main as taken at the hydrant, is 100 pounds and that on the first floor of an adjacent dwelling is only 3 or 4 pounds. This condition when discovered can be corrected only by replacing the old service pipe by a new one. It can be prevented to a great extent when the service is first laid by exercising care in the selection of materials used and by procuring good workmanship.

DISCUSSION

Mr. George Houston: Mr. President, in cities where most of the water used is used without being metered, the advice and recommendations contained in this paper are very good and opportune. The speaker has had several years' experience in this way of furnishing water, and all of the troubles mentioned therein are very real. In order to get away from them, we adopted the general metering system, and our troubles vanished. It was found that notwithstanding all of the rules recommended in this paper, the waste of water went on just the same. Inspections following inspections, a month apart, three months apart, six months apart, and sometimes immediately after making the inspection, have found the parties using water wasting it just the same, or permitting it to run from the faucet to cool ginger ale, as has been mentioned here, in summer, or refrigerating anything that they wished to keep cool. Those in charge of the premises would promise not to do so any more, but have been found inside of twenty-four hours doing the same thing again. In order to stop water waste in that way it would be necessary to have a man on the job all the time. There is no other way to stop it. The only thing that is on the job all the time to look after waste is the water meter. If all of the cities or water companies that are troubled with the sort of complaint mentioned in this paper would adopt a general metering system they would do away with very much of their trouble in that line. We are not worried in our city to any extent about any water going to waste.

In one case where we had a consumer that we thought was using more water than he should under flat rates, we raised the assessment, and he came down and swore off a number of charges that we had made against him, and of course his oath had to be taken and a reduction made in the items charged for. Shortly after that took place the speaker prevailed on the water board to give us authority to

install a meter on the premises at the city's expense. The party was away at that time on a vacation and there was nobody around the premises but the hired help. We installed the meter at the curb line, and the first month after that his water bill which had previously been about $8 semi-annually was $14 and some cents for the month. That was the result of the installation of a meter. One of our leading physicians who was paying $6 semi-annually objected to that rate, and the rate was cut down to $4. We put a meter on his premises immediately after that, and the first month his bill was $14.

Those are two cases, but a great number similar to them could be enumerated. The speaker is a member of our board of plumbing examiners and has been since its organization. We do not attempt to control the plumbing inside of the house, except as may be necessary from the standpoint of health, namely, with reference to sewerage plumbing. We have never attempted to have anything to say about the plumbing arrangements in the house otherwise. We put the water service in up to the curb line. The property owner through his licensed plumber takes out the permit and goes on into the house with it. We simply require that the city shall be secured against any waste or leakage that is the fault of poor plumbing in the premises by having a meter placed there by the property owner. We require plumbers to give a bond, not for the work done inside of the house, but simply to protect the city against accidents occurring through neglect to properly perform his work in the street.

Mr. A. A. Reimer: The paper as a whole is an excellent one and a timely one for us to consider. The point mentioned by the last speaker is one to which we can all give a great deal of thought, namely, the necessity of the control of fixtures inside of buildings, whether that should be done through the board of health or the water department or any other special department. The speaker's own feeling in the matter is that what is generally included as the sanitary plumbing should be directly under the charge of the board of health, because that is the only point where the health factor enters in. It is best to strengthen the powers of the boards of health at all times; by all means let them have the control of the sanitary plumbing.

The rules laid down for governing plumbers as outlined in the paper are accepted as good practice and represent the requirements of examination and licensing that are pretty commonly used.

We go a little further in our own practice in requiring that every employee of a licensed plumber shall have a card of identification on his person at all times during working hours, so that we may be sure that no employees are working except under license issued by the department. We have a provision that a licensed plumber may lay service pipe from the curb line into the house; but we require that such work shall be inspected at a nominal charge by ourselves. The fact is that in all the years that we have had that provision, no licensed plumber has ever taken advantage of that permission. We do all the work from the main to the curb, and we can do it so much cheaper than the plumber, that is, cheaper to the consumer or to the owner than the plumber, that we are not troubled by ever having to inspect pipes laid in streets by licensed plumbers.

The question of leakage in house fixtures became a very serious one with us. Five years ago we made a pitometer survey of the entire city so far as the mains were concerned. After having proved definitely that the leakage in the system of mains comprising nearly 80 miles was almost negligible, we carried the inspection farther, putting the same survey on, and demonstrated absolutely that 54 per cent of the leakage which was disclosed by the pitometer survey was traceable to the house fixtures. There was a very small amount in the mains but a very much larger percentage in the house fixtures. That was the beginning of a campaign to eliminate this heavy amount of leakage, and from then on we have been metering rapidly.

Probably we have all had the experience of having a licensed plumber tell some of our customers, in case of a high bill, that it was impossible that the customer could have used that amount of water during the length of time covered by the bill; that it could not possibly pass through the meter; that the meter is wrong. Now we have not been at all bashful in our remarks about plumbers who were telling our customers that. We have simply said in so many words without mincing matters, that the plumbers did not know what they were talking about. We are gradually making the plumbers come to time on that, and we have found that they do not know very much about the quantity of water that will pass through a given size of pipe. We are getting fewer and fewer of those complaints; but there are still some plumbers who think they know more than any water department can show them in regard to the amount of water that can pass through certain pipes under certain pressure. Our men are trained to find leaks on the customer's line. When we

have trouble through the agency of the plumber telling people that there is no leak in certain premises, we go there and show them the leaks.

Now the speaker believes in the control of the plumbers, and when we find that a certain plumber has reported that there is no leak we get after that man and show him how to detect leaks in the right way; so that gradually that trouble is lessening.

Mr. Highland has stated that taps and service pipes should all be of the size prescribed by the water department. That is all right. Then he says that they shall be run into the buildings only by licensed plumbers who must file an application stating the material to be used. That provision is unwise to be worked into any plumbing code in the country. The time is coming when more and more of the departments and companies supplying water will insist on carrying supplies from the main to the meter point. If you have the meters at the curb line, that is all right and very easy; but the majority of us do not stop at the curb for metering, we go on into the house and set the meter in the house or the factory or whatever it may be. You do not find any gas company that allows a licensed plumber to lay any part of their services into the house; you do not find the electric light companies allowing some contractors to run wires up to the meter from a given point out on the feed line; and there is no difference in that regard between water, gas and electricity. We must stop this practice of allowing licensed plumbers or any contractors to carry the water from the main. By our carrying the services all the way into the house or building, whatever kind it may be, we have eliminated much of these troubles that are complained of.

The speaker wants to agree with the last speaker that his entire paper points to the need of meters; and when we have meters on 100 per cent of our total services we will find that we will need just a very few simple, effective rules to govern this whole situation and not an elaborate plumbing code.

Mr. A. Prescott Folwell: In regard to what the last speaker said as to the desirability of having the plumbing run all the way into the house by the city, the speaker understands that the code of rules suggested here would have the city run the plumbing to the curb; but thinks the idea of both speakers was to have the city run the pipes to the meter box; it happens, however, that the writer of

the paper lives in West Virginia where his meters are placed at the curb, and the last speaker lives in New Jersey where the meters are placed in the cellar. Probably they agree that the city should run the pipe to the meter wherever it is placed, and the private plumber run it from the meter to the fixtures.

Mr. J. N. Chester: The inquiry will naturally come from private companies, as to who is going to bear the expense of running to the curb, or who is going to bear the expense of running to the cellar? If the water company lays the pipe into the cellar, who is going to stand the additional cost? The rates that must be charged either by public or private water works are in justice predicated on the investment, and if the services are run into the cellar at the expense of the plant it will mean an additional investment equal to the amount that either the city or the private company must pay in so doing.

All of these things must be taken into consideration with reference to the return the ownership gets from the investment, whether it is a private company or a municipal corporation. Another thing that has interested the speaker in this paper and in the first speaker's remarks is in regard to the amount of water that is not accounted for. There are various estimates made as to what this amounts to, and that is the thing that has interested the water consumption committee and that we endeavored to get at; the one thing regarding which we would like to see some data brought out in this discussion; that is, if it is not too far afield from the character of the paper.

Mr. Theodore A. Leisen: There are several questions in this paper that the speaker thinks are worthy of very serious consideration. The inspection of plumbing generally would, in the opinion of the speaker, be better left to the boards of health or such other parties as may control it. Where there is a sewerage board it might be very appropriate for them to inspect all plumbing; the inspection of the water pipes unquestionably ought to come under the water board or water department, and in that inspection for the protection of the water board or department it is essential that they should determine the size of the pipe not merely from the main to the curb, but also at least through the lower portion of the house. Many superintendents have probably had experience with complaints from lack of supply in the upper stories of houses. The water department

is almost invariably blamed for not furnishing a proper supply, when in most instances the trouble is due to the fact that the pipes leading through the basement are too small to supply the number of headers running to the upper stories. That is one point that the inspection by the water department ought to cover.

We all recognize that the question of leakage would be largely controlled by the universal adoption of meters. If metering were universally adopted the waste would not be a matter of very serious consideration to the water department, unless it was deficient in the source of supply. Consumers should only use the water that they require for legitimate purposes and not allow it to run to waste.

The paper as a whole, in some points goes rather too much into detail as to the method of carrying out the suggestion and rules; that should be left in rather more general terms than it has been in this paper, because of the varying conditions in different localities.

Mr. F. J. Connor: Will Mr. Reimer please state what kind of services they use; are they lead?

Mr. A. A. Reimer: Our practice has been for small services up to 1-inch tap, to lay heavy lead pipe from the mains to the curb line, and there change to galvanized wrought iron pipe of the small sizes, and use wrought iron all the way through, the very highest grade of pipe that we can get.

Mr. F. J. Connor: How do you handle your consumers? Do you make them put up a deposit? Have you a schedule of cost that covers the whole service from the main to the curb along the short side of the street? Or do you figure from the short or long side of the street?

Mr. A. A. Reimer: East Orange is a municipal department, not a private water company, supplying the city. We have a set of rules governing all those matters. We require what might be called a "permit fee," and we make no charge for the tap or supply pipe as we call it from the main to the curb. From that point on we charge a given price per foot for the amount of pipe laid, so that a man away back from the street further than some one else pays no more to cover the additional distance. They pay a unit price per foot for the service pipe from the curb line into the building, varying with the size of the pipe.

Mr. F. J. Connor: In other words, the service from the main to the curb is free service?

Mr. A. A. Reimer: We charge the consumer nothing for that. We do not consider that the permit fee paid covers the cost of the service from the main to the curb. We charge that to capital account.

Mr. F. J. Connor: In that case the fee that you charge practically covers the cost of the service, so that in reality it is not a free service?

Mr. A. A. Reimer: We do not consider it as in any sense a permit for the service. We capitalize our connections from the main to the curb, and the fee paid is purely a license fee, that is all, and it is so regarded in our finances.

Mr. F. J. Connor: Until about one year ago the city of Sioux Falls determined to put in the service from the main to the curb free of cost. A legislative act was passed and now we charge from the main to the curb the actual cost. Of course labor conditions and the condition of the soil and all that make a difference in the cost; but we only charge actual cost. It was found that in many cases those who ordered services put in failed to pay for the same promptly and the commissioners, finding that there was an accumulation of such accounts, that people were slow in paying for services, took up the question as to whether we would continue to put in the services in that way or whether the applicants should be required to put up a deposit at the time they made their application. Now we have a law in reference to city improvements, such as paving and other street improvements, and we are trying to get away from all of the old galvanized services. We had two water companies in Sioux Falls, and where we cut off from the old company mains and connected to the new company ones on one side of the street we would extend the service to the new main, and on the other side we would cut it and connect to the other main which, of course, crossed. We have services that are probably twenty years old. We have passed an ordinance and are trying to persuade the people to put in all lead services from the main to the curb.

We have had some trouble with complaints of short supply through the party putting on a smaller meter than the service called for; for

instance where the consumer had a $\frac{3}{4}$-inch service he would only want to put on a $\frac{5}{8}$-inch meter. The only remedy for that was that we would ask them to put on a larger meter when the service was of sufficient size, and convinced them that it was the meter, and not the service that was at fault. The service question is one that is confronting the speaker, who has been a plumber a good part of his life, but does not like to fall into the hands of every plumber, because a lot of them are not good lead workers. We use wiped joints, and if those joints are badly made and a leak starts, of course, the superintendent is called out of bed at night to look after the leak. You do not have any redress from some of those plumbers because they are irresponsible. The departments or water company ought to maintain and take care of the service from the main to the curb line, and that is as far as they should go; from that point you should turn it over to the property owner. Another method of putting in services is to do it by contract, and advertise for bids for the excavation and all. We charge $3 for a tap and then insist upon our men laying the service and seeing to it that the work is thoroughly done.

Mr. J. N. Chester: The speaker would like to ask Mr. Reimer whether all of his services are metered?

Mr. A. A. Reimer: No, sir. We have about 65 per cent metered and in another two years we will probably have 100 per cent metered. In the great majority of cases we set the meter inside of the basement of the building. In a few cases we are forced to set them at the curb.

Mr. H. B. Morgan: If you set the meter in the basement why did you change from lead at the curb?

Mr. A. A. Reimer: The primary reason was the element of cost; the other is the element of larger flow. The cost of 1-inch galvanized pipe, of the very highest grade is only about one-half that of lead pipe, say of $\frac{1}{2}$-inch in diameter. In our case, we have to use AAA lead pipe on account of our pressure. If we use $\frac{1}{2}$-inch pipe all the way through from the main to the building we are introducing a very large friction element which we can avoid by increasing the $\frac{1}{2}$-inch lead pipe up to 1-inch galvanized iron pipe at the curb

and give the consumer a very much freer line conducing to a better flow of water.

Mr. H. B. Morgan: Do you feel that the board or company is fully protected from leaks when using galvanized iron pipe?

Mr. A. A. Reimer: We have been in very close touch with the wrought iron pipe question owing to the fact that the speaker has been on the committee that has been taking up the question of wrought iron pipe, and feels that he is in a pretty safe position in specifying wrought iron pipe, since he knows what he wants and knows how to get it too. Specify nothing but strictly genuine wrought iron pipe; it is to be had if you want to get it.

Mr. H. B. Morgan: Those of us who are not so well versed in pipes as the gentleman who just spoke, perhaps might be fooled as to whether the pipe was galvanized iron or galvanized steel. There are perhaps not a dozen men in this hall who can tell the difference between the two. The speaker knows he could not, but he does not claim to be an expert.

The speaker cannot see any very good logic in requiring lead pipe from the main to the curb and allowing wrought iron pipe to be installed from the curb to the building where the meter is placed in the cellar. If the meters were placed at the curb it would make very little difference to the water company or the water board whether the pipe from the curb to the building was iron or lead, for the meter would register the leaks. Our company requires that all pipes of 1 inch and less, where laid under the ground or floor of a building, shall be extra strong lead pipe. We also require plumbers to leave the ditch open so that we may inspect the pipe after it is laid. This is done for the protection of the consumer, as well as the company.

Recently a meter was set at the curb on a service supplying a building with a single fixture, a kitchen sink. In one month 300,000 gallons of water passed through that meter. At one time the supply of water for this premises was taken from a hydrant located in the front yard. Afterwards the hydrant was removed and the pipe extended to the kitchen sink in the building. The pipe from the curb to the hydrant was laid many years ago and was iron. We did not require them to replace the iron pipe with lead, but we did

require lead pipe from the location of the hydrant into the building. The leak that caused 300,000 gallons to pass through the meter in one month was located in the iron pipe, which was full of holes. This pipe had probably been leaking for a good many years and the leak was only detected by the placing of the meter.

It would seem that this convention should understand these things thoroughly, and should realize that it is our duty to provide and use the best material obtainable for service pipes, not only for our own protection from waste of water through leakage, but also for the protection of the consumer. In fact, our State Utilities Commission insists that when meters are set on services a thorough test shall be made to see if there are any leaks in the consumer's pipes, and if leaks are found, to notify the owner to make repairs.

We might go on at length with this discussion, and afterwards go home and handle this subject as we think best and to our own benefit. The speaker quite agrees with some of the gentlemen here that plumbers are the poorest lot of mechanics that we have to deal with, but we are up against it, and will have to handle them as best we can; but we should insist on the one point, that all ditches where plumbers are laying service pipes should be left open for inspection before filling in. In some cases plumbers neglect to do this. We then require them before the water is turned on to uncover the pipe.

Mr. J. M. Diven: One reason for using a better quality of pipe to the curb line is to avoid tearing up the streets to make repairs.

Mr. Theodore A. Leisen: Mr. Morgan struck one very important keynote when he referred to the fact that any inspection or any action by any of the departments should undertake to carry with it just as full responsibility of protecting the owner of the premises as it does of protecting the interests of the department represented.

There is no question but that it is desirable for the water department to run all services at least to the curb, and preferably to what is commonly designated as the property or building line. Whether that is done at the expense of the consumer or not, is purely a question of how the revenues are derived. In the final analysis the consumer must pay for that pipe either directly or indirectly; it is just the difference between direct or indirect taxation as applied to general improvement.

If a certain class of pipe is required from the main to the curb the same quality should be continued as far as the department's responsibility goes in the laying of that pipe, and the very small difference in expense would hardly warrant using inferior grades of material, if it is inferior. If it is not inferior, then there is no reason for discrimination between either one side or the other of the curb, the responsibility will have to be assumed by the water department. When the house is built on the property line as is usually the case in the business section, going a foot or two further in to make the connection through the wall to connect with the meter is a small matter; but if the house or store sits back 25 or 30 feet from the street line it necessitates carrying the pipe through a larger amount of private property, and then there might be a serious question brought up as to whether the department should do that or leave it to the owner.

On the question of paying for the services, the speaker might refer to an experience in Louisville, Kentucky, where for a long number of years the services were put into the property line from the main free of cost. Later, after several years, that method was changed and the consumer was charged with the actual cost of the services in each instance. There were some objections raised at first, but owing to the absolute confidence in the board of water commissioners at that time the matter passed over and the public was very well satisfied. Later, after that condition had been in force for about four years, they went back to the old method of putting the services in free. The cost of a $\frac{5}{8}$-inch service in Louisville covering a period of years and taking an average length of from 30 to 32 feet on a $\frac{5}{8}$-inch lead service, was less than \$12. It averaged that for several years—between \$11 and \$12, including the corporation cock, the stop-box at the curb and the lead pipe running from the stop-box into the building line; so that the conditions there would be probably more or less the same as they are in any section of the country where they do not have to blast through rock. With that cost the speaker can hardly see why there would be any excuse for considering any other class of material so far as the expense item is concerned.

A Member: Does \$12 cover the cost of replacing the pavement?

Mr. Theodore A. Leisen: Yes, on an average, that covers everything.

A MEMBER: Is the committee that is investigating wrought iron pipe also investigating the relative desirability of wrought iron pipe as compared with lead pipe?

MR. A. A. REIMER: Our committee has that matter under investigation at the present time. We have been working on that for the past two years.

MR. H. C. HODGKINS: The speaker will look for the results of the committee's work with a great deal of interest. He thinks there is a very widespread mistaken idea as to the relative desirability of the two kinds of pipe. Certainly the information should be very valuable to this Association as superintendents.

MR. B. F. SOUDER: Our department puts in the services and controls the services from the main to the curb. The price of the services is governed according to the width of the street; for instance, the property-owner comes to the water department to order a service, we ask him what size service he wants. By the way, we use tin-lined iron pipe from the main to the curb with the corporation and the tail piece as we call it.

Our charges for street services are as follows:

WATER DEPARTMENT OF ATLANTIC CITY

Price List of Street Services
To take effect February 16, 1909

DIAMETER OF PIPE	¾-INCH	1-INCH	1¼-INCH	1½-INCH	2-INCH
Streets and alleys 25 feet wide and less	$11.00	$14.00	$23.00	$29.00	$40.00
Avenues 30 feet wide	13.50	18.25	25.00	32.50	46.00
Avenues 36 feet wide	14.50	19.75	27.00	36.00	50.00
Avenues 50 feet wide	17.00	24.00	33.00	43.00	59.00
Avenues 75 feet wide	22.00	30.00	40.00	55.00	75.00

Add to above price $2.00 for bitulithic or asphalt streets.

Highway department charge for opening streets in addition to above schedule:

Gravel	$1.10
Macadam	4.90
Brick	19.00
Telford	16.80
Asphalt between Main and New Jersey	23.33
Asphalt between New Jersey and Florida	15.90
Asphalt between Florida and Albany	$23.33
Bitulithic—Atlantic Ave.	25.00
Bitulithic—Virginia, South Carolina, Ocean and Tennessee	32.90
Wooden block	33.90

When they come to the office to order a connection with the main and state the location, we instruct the applicant that he must go into the highway department, take out a permit to open the street and bring that permit back to the water office. We then issue the permit, they paying cash for the service in advance. If the streets are paved with bitulithic, asphalt, brick, macadam or gravel, etc., the cost of opening the street varies; for a gravel street they would have to pay \$1.10 to the highway department for a permit to open the street; for macadam, \$4.90; for brick, \$19; asphalt, between Maine and New Jersey Avenue, \$23.33; asphalt, between New Jersey Avenue and Florida Avenue, \$15.50; bitulithic on Atlantic Avenue, \$25; on Virginia Avenue, South Carolina Avenue, Ocean Avenue, and Tennessee Avenue, \$32.90; wooden block, \$33.90.

If it is a bitulithic paved street it is harder to open and an extra cost of \$2 is added when they pay for the permit for the service. We maintain that service; we don't aim to make anything, but we try not to lose on it.

We use tin-lined pipe that costs us in Atlantic City 40 cents a foot for ¾-inch pipe, and is said to have life everlasting; so that when they come to order a service and say, "Well, it seems to me that is a pretty stiff price," we say to them, "It has life everlasting, and never has to be renewed."

The size of taps is governed according to the size of the building. If it is a large hotel and they want larger than 2-inch we give 4-inch; if they want 3-inch we give them 4-inch instead of 3-inch, because we can put in a 4-inch cast iron service cheaper than we can put in a 3-inch wrought iron service. We don't recommend 3-inch wrought iron for hotels, but we give them cast iron. We control and own the meters. We buy the meters and set them at the curb. The meters are invariably all at the curb. We set them there and the plumber takes the service from there.

We compel the plumbers to take out a license. After the work is completed and they are ready to have the water turned on we send an inspector there who inspects the whole building and sees that the work is all right and everything is tight. Then we turn the water on if they have made an application for water. They pay in advance the minimum rate which is governed according to the number of rooms and fixtures there are in the house.

Small meters are read quarterly; the large meters we read monthly; so that we keep in touch with them. When the meters are read the

book is left in the office and is gone over there. If we find that they have used more water during the month than they are allowed by the minimum rate we immediately send them a postal card notifying them that their minimum has been exceeded; that they have used a certain number of cubic feet equivalent to so much money. We send the inspector there, and after we get his report we notify them what the trouble is, and the next month if the inspector goes there and finds that they have not attended to it in accordance with the notice, we shut the water off until they do attend to it. Our minimum rates are as follows:

ATLANTIC CITY WATER DEPARTMENT

Information for Water Consumers

		Cub. feet	Gals.
Minimum Rate $ 5.00	entitles you to..........	5,555	41,667
10.00	....	11,111	83,000
13.00	....	14,444	108,333
18.00	....	20,000	150,000
25.00	....	27,777	208,333
35.00	....	38,888	291,667
50.00	....	55,555	416,667
75.00	....	83,333	625,000

Mr. George Houston: Realizing that we are taking up a lot of time with this discussion, the speaker did not divert any more than necessary or attempt to cover any more ground, but is reminded of a story, in listening to these talks, of the foolish child that stuck its finger on the hot stove and then yelled for somebody to assist it out of its trouble by putting more wood into the fire. It is astonishing how men that have been engaged on water works matters as long as some of these gentlemen have will keep on inviting trouble into their own camp. What excuse is there for water works men to assume that a private or a municipally owned company should take on the responsibility for putting the water plumbing into a man's house. There is no excuse for it on earth. If you assume the control of the plumbing inside of a man's property, and go there and inspect it after it is installed and pronounce it O.K., the next time he comes in to pay a bill that is $5 or $6 higher than it ought to be, on account of leaking pipes or fixtures, what are you going to say? Can you tell that man conscientiously that he has to pay the bill? No. That is the experience of every water works man, no matter whether he is col-

lecting for a private company or a municipal plant. Why, that man will at once tell you, "You have had the plumbing inspected, and you ought to know, or see to it that it is all right." Why should we make it our business to inspect house plumbing. We told a man that came in to pay a bill of $52 for one quarter, when his average bill was $3.75, that we had nothing to do with the plumbing. If you take on responsibility for the plumbing you are holding yourselves responsible for the shortcomings of any job, and you cannot get away from it. Why do you want to invite that trouble upon yourselves all the time? Go home and think it over, and you who have not had experience in that line, think it over good and strong!

Mr. W. F. Wilcox: The speaker had occasion about a year ago to try to tabulate the amount of water that could be accounted for by different plants, and arrived at the conclusion that the average amount of water accounted for by different plants was somewhere in the neighborhood of 75 per cent; that 80 per cent was high, and 85 per cent was excellent; that there were very few plants according to their statements that had accounted for 85 per cent of their water. Below 75 per cent would indicate bad management. The report obtained and the result of all the compilations secured showed the above facts.

Somebody here asked the question about buying pure wrought iron pipe. The speaker seriously doubts if there is enough pure wrought iron pipe made in the United States to supply the demand. The pipe people are spending a great deal of money in maintaining a large laboratory to test their pipe, and they are sending out men to investigate any pipe which fails, because they want that information. It would be wise for every man to determine, taking into account his own conditions, whether he can use lead pipe, lead lined pipe, or wrought iron pipe. It is doubtful whether your committee will get enough reliable data to lay down any hard and fast rule that is going to do for any considerable number of plants.

Mr. Francis C. Hersey: From the last speaker's statements, the percentage of unaccounted-for water was leakage in the mains and perhaps meter under-registration. Is that correct?

Mr. W. F. Wilcox: Yes.

Mr. George Hornung: Some forty years ago the speaker became manager of a water works, and the question of accounting for the water pumped and consumed came before him. To do this properly, the water pumped was measured, so as to be able to report not only the actual consumption of water by the city, but also to keep informed on the efficiency of the pumping plant. In this case there was a divided reservoir; in one of the basins was constructed a weir, and the caretaker of the reservoir was taught to use the hook gauge, and when he became proficient in this, weir readings were taken daily between the hours of twelve and one o'clock. At the same time and hour, counter readings were taken of the revolutions made by the engine. These weir readings and revolutions of engines were sent to the speaker daily, and the computed results from this data showed that the per capita consumption did not exceed 30 gallons per day.

About twelve years ago the speaker again became the manager of this plant, and upon that occasion the city was about to issue bonds for the purchase of additional pumping machinery. From a preliminary investigation of the machinery it was found to be large enough, if put in thorough repair, to amply supply the city for years to come. For ascertaining the amount of water the engines were pumping in the condition they were in, a Venturi meter was placed in the pipe through which the engines were pumping, and the results obtained indicated that the loss of pump action or slippage was 50 per cent. After the repairs were made meter measurements of the water discharged by the pumps were again taken, which gave a loss of pump action of a fraction less than 3 per cent.

The water consumption per capita, as usually published in the annual water works reports, is generally based on plunger displacement of the pump, with a small correction for pump slippage, which cannot be relied upon, for reasons as heretofore stated, unless the water delivered by the pumps is actually measured. As an illustration of the unreliability of the method of reporting the water delivered by a pumping engine when based on plunger displacement, the following instance may be cited: in the investigation of a large pumping station an engine with a rated capacity of 24,000,000 gallons per day, was found operating for two weeks without pumping any water; or in other words the slippage or loss of pump action in this case, was equal to 100 per cent; but with all that, the daily read-

ing of the counter on the engine, and its computed plunger displacement, was sent by the chief operating engineer to the office of the superintendent of that water works, and there accepted without being questioned in entering it up with the remaining engines in operation as water pumped and consumed. The discharge pipe or force main of this engine approached the reservoir on a uniform ascending grade, and finally curved vertically, with its end flush with the bottom of a large flume constructed of masonry alongside of the reservoir, through which the water was led to the latter. Into this flume six other engines were delivering their water at one time; hence the failure of this particular engine went undiscovered until all of the others were shut down and this one operated by itself.

Mr. Wirt J. Wills: Mr. President and gentlemen, inasmuch as this discussion has covered almost the entire life history of every other water department it had better get a look-in now relating to the conditions in Memphis, which has been a municipally owned plant. The connection from the main to the curb is paid for by the city and put in by the water department. The city has a plumbing inspector who inspects the plumbing inside of the building.

Mr. W. F. Wilcox: Mr. Hornung took up the question of pump slippage as affecting unaccounted-for water. The speaker cannot see how anybody would carry pump slippage over into that account. Any man with a very rough apparatus can find out what his pump slippage is.

THE SECTIONS

NEW YORK

The first 1915–16 meeting of the New York Section was held at the Manhattan Hotel, October 20, 1915, Mr. Robert E. Milligan presiding. Eighty members and guests were registered. Luncheon was served, after which Mr. Carl P. Birkenbine read a paper "Variations in Precipitation as Affecting Water Works Engineering," illustrated by lantern slides. The paper was discussed by Messrs. A. J. Provost (using lantern slides), John C. Trautwine, Jr., William W. Brush, Sidney K. Clapp and Francis F. Longley. Mr. J. Waldo Smith presented some lantern slides of the Los Angeles Aqueduct, accompanying them with a running talk.

The New York Section will have two more meetings during the winter 1915–16, the third Wednesdays in December (15th) and February (16th).

ILLINOIS

The fall meeting of the Illinois Section was held at Hotel Sherman, Chicago, October 19, 1915. Luncheon was served at the College Inn, after which automobiles, furnished by the Chicago members of the Section, and representatives of supply houses, took the members to the new Municipal pier, the Lakeview pumping station, the Wilson Avenue tunnel on the lake front, the site of the new pumping station at Mayfair, and the new Municipal shops. Dinner was served at the Hotel Sherman, after which the following papers, illustrated by lantern slides, were presented:

"Design and Construction of the New City Intake," by Mr. John Ericson; "Water Softening Practice," by Mr. Samuel A. Greeley.

Mr. W. J. Spaulding also presented a paper "Saving by Preventing Water Waste."

A letter was received from the American Society of Civil Engineers, asking for the coöperation of the Section in bringing about unity of action where the advancement of engineers interested may be jointly

undertaken. The chairman was authorized to appoint a committee to investigate and report.

The next meeting will be held, jointly with the Illinois Society of Engineers and Surveyors, at the University of Illinois, Urbana, January 25 to 27, 1916. Papers of special interest to water works men will be given on January 25, and the business of the section will be transacted on that date. On the 26th and 27th joint sessions will be held. All members of the American Water Works Association are invited to attend.

CENTRAL STATES

The first meeting of the Central States Section was held at the Chittenden Hotel, Columbus, Ohio, October 20 and 21, 1915. Papers were read as follows:

"Sources of Water Pollution," by Mr. John W. Hill; "The Development of Rapid Sand Filters in Ohio," by Mr. Phillip Burgess, and a paper by Mr. McCullom (title not reported).

The following officers of the section were elected:

Chairman, Mr. Jerry O'Shaughnessy, Columbus, Ohio.

Vice-Chairman, Mr. Elroy Tobias, Hastings, Mich.

Treasurer, Mr. A. W. Inman, Massillon, Ohio.

Directors, Mr. C. W. Wiles, Delaware, Ohio; Mr. Charles Londick, Three Rivers, Mich.; Mr. H. H. Frost, Akron, Ohio.

IOWA

A meeting of the Iowa Section has been called for December 3 and 4, 1915, but no program or particulars have been received. At this meeting the organization of this Section will be perfected and officers elected.

PHILADELPHIA

Members of the Association residing in Eastern Pennsylvania, New Jersey south of and including Trenton, Delaware and Maryland, have petitioned for the formation of a section, and the Executive Committee has granted the request. No meeting has as yet been held for organization.

OFFICERS 1915–1916

President

NICHOLAS S. HILL, JR., Consulting Engineer, 100 William St., New York, N. Y.

Vice-President

LEONARD METCALF, Consulting Engineer, 14 Beacon St., Boston, Mass.

Treasurer

JAMES M. CAIRD, Chemist and Bacteriologist, 271 River Street, Troy, N. Y.

Secretary-Editor

JOHN M. DIVEN, Superintendent of Water Works, Troy, N. Y.

Trustees

Term Expiring 1916

THEODORE A. LEISEN, General Superintendent, Board of Water Commissioners, Detroit, Mich.

CHARLES R. HENDERSON, Manager Water Works, Davenport, Ia.

Term Expiring 1917

ALLEN HAZEN, Civil Engineer, 42nd St. Building, New York, N. Y.

ALLAN W. CUDDEBACK, Engineer and Superintendent Passaic Water Company, Paterson, N. J.

Term Expiring 1918

CARLETON E. DAVIS, Chief of Bureau of Water, Philadelphia, Pa.

C. H. RUST, City Engineer and Water Commissioner, Victoria, B. C.

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NICHOLAS S. HILL, JR., President

GEORGE G. EARL	CARLETON E. DAVIS
ROBERT J. THOMAS	JAMES M. CAIRD
H. E. KEELER	LEONARD METCALF
JOHN M. DIVEN	THEODORE A. LEISEN
CHARLES R. HENDERSON	ALLEN HAZEN
ALLAN W. CUDDEBACK	C. H. RUST

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J. WALDO SMITH, President New York Section, Chief Engineer Board Water Supply, Municipal Building, New York, N. Y.

W. J. SPAULDING, President Illinois Section, Commissioner of Public Property, Springfield, Ill.

JERRY O'SHAUGHNESSY, Chairman Central States Section, Superintendent Department of Water, Columbus, Ohio.

WILSON F. MONFORT, President Chemical and Bacteriological Section, 506 N. Vandeventer Ave., St. Louis, Mo.

STANDING AND SPECIAL COMMITTEES 1915–1916

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H. E. Keeler, Chairman, President Rogers Park Water Company, 633 The Rookery, Chicago, Ill.

Howard A. Dill, Superintendent Water Works, Richmond, Ind.

Henry B. Morgan, Manager Water Works Company, Peoria, Ill.

PUBLICATION

John W. Alvord, Chairman, Consulting Engineer, 1417 Hartford Bldg., Chicago, Ill.

Dabney H. Maury, Consulting Engineer, 1137 Monadnock Block, Chicago, Ill.

Edward Bartow, Director State Water Survey, Urbana, Ill.

H. E. Keeler, President Rogers Park Water Co., 633 The Rookery, Chicago, Ill.

John M. Diven, Editor, 47 State Street, Troy, N. Y.

MEMBERSHIP

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James H. Caldwell, Civil Engineer, Troy, N. Y.

Morris R. Sherrerd, Chief Engineer Street and Water Commission, Newark, N. J.

NOMINATING

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Morris R. Sherrerd, Chief Engineer Street and Water Commission, City Hall, Newark, N. J.

Robert J. Thomas, Superintendent Water Works, Lowell, Mass.

M. L. Worrell, General Manager Water Works, Meridian, Miss.

H. Hymmen, Superintendent Water Works, Berlin, Ont., Canada.

ELECTROLYSIS

Albert F. Ganz, Chairman, Professor Electrical Engineering, Stevens Institute of Technology, Hoboken, N. J.

Charles R. Henderson, Manager Water Works, Davenport, Iowa.

Daniel D. Jackson, Sanitary Expert, Engineers Building, Columbia University, New York, N. Y.

E. E. Minor, Superintendent Water Company, New Haven, Conn.

Robert A. Jackson, Superintendent Insurance and Water Company, Norristown, Pa.

REVISION OF STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIALS

John H. Gregory, Chairman, Consulting Engineer, 170 Broadway, New York, N. Y.

W. H. Randall, Superintendent of Maintenance, Water Department, Toronto, Ont.

Walter Wood, President Millville Water Company, 400 Chestnut Street, Philadelphia, Pa.

Frank A. Barbour, Hydraulic and Sanitary Engineer, 1120 Tremont Building, Boston, Mass.

Edward E. Wall, Water Commissioner, St. Louis, Mo.

STANDARD SPECIFICATIONS FOR WROUGHT IRON PIPE

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Robert Spurr Weston, Consulting Sanitary Engineer, 14 Beacon Street, Boston, Mass.

George C. Whipple, Consulting Engineer, Harvard University, Cambridge, Mass.

Frank E. Hale, Chemist, Mt. Prospect Laboratory, Department of Water Supply, Gas and Electricity, Brooklyn, N. Y.

Lewis I. Birdsall, Superintendent of Filtration, Minneapolis, Minn.

DEPRECIATION

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Daniel W. Mead, Professor Hydraulic Engineering, University of Wisconsin, Madison, Wis.

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Wynkoop Kiersted, Consulting Engineer, 640 Midlands Building, Kansas City, Mo.

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W. F. Wilcox, Central Water Works, Ensley, Ala.

PREVENTION OF STREAM AND LAKE POLLUTION

Theodore A. Leisen, Chairman, General Superintendent Board of Water Commissioners, Detroit, Mich.

Paul Hansen, Chief Engineer State Board of Health, Urbana, Ill.

William C. Lounsbury, General Superintendent Filtration Plant, Superior, Wis.

M. N. Baker, Vice President New Jersey State Board of Health, Editor *Engineering News*, New York, N. Y.

C. A. Emerson, Jr., Assistant Chief Engineer, State Department of Health, Harrisburg, Pa.

STANDARD SPECIFICATIONS FOR HYDRANTS AND VALVES

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Morris R. Sherrerd, Chief Engineer, Street and Water Commission, Newark, N. J.

James H. Caldwell, Civil Engineer, Troy, N. Y.

J. M. Diven, Superintendent Water Works, Troy, N. Y.

Dennis F. O'Brien, President A. P. Smith Manufacturing Company, East Orange, N. J.

W. R. Conard, Civil Engineer, Burlington, N. J.

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William W. Brush, Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Building, New York, N. Y.

John H. Dunlap, Assistant Professor Hydraulic and Sanitary Engineering, University of Iowa, Iowa City, Iowa.

STANDARD FITTINGS FOR WATER METERS

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Edward L. Peene, Superintendent Water Works, Yonkers, N. Y.

Harry A. Lord, Superintendent of Water Works, Ogdensburg, N. Y.

Howard M. Ely, Superintendent of Water Company, Danville, Ill.

J. A. Tilden, Mechanical Engineer, Hersey Manufacturing Company, Boston, Mass.

PLUMBING CODE AND CONTROL OF PLUMBERS

Scotland G. Highland, Chairman, Secretary and Superintendent of Water Works, Clarksburg, W. Va.

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William McCarthy, Superintendent Water Works, Bluefields, W. Va.

James R. McClintock, Hydraulic and Sanitary Engineer, 170 Broadway, New York, N. Y.

MECHANICAL ANALYSIS OF SAND

Phillip Burgess, Chairman, Hydraulic Engineer, 828 Columbus Savings and Trust Building, Columbus, Ohio.

George W. Fuller, Consulting Engineer, 170 Broadway, New York, N. Y.

Edgar M. Hoopes, Jr., Civil Engineer, Chief Engineer Water Department, Wilmington, Del.

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Samuel R. Hatch, Engineer State Public Utility Commission, 8 Wenzell Apartments, Madison, Wis.

J. Walter Ackerman, Superintendent Water Board, Auburn, N. Y.

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